U. S. DEPARTMENT OF AGRICULTURE.

BUREAU OF PLANT INDUSTRY—BULLETIN NO. 53.

B. T. GALLOWAY, *Chief of Bureau.*

THE DATE PALM

AND

ITS UTILIZATION IN THE SOUTHWESTERN STATES.

BY

WALTER T. SWINGLE,

Physiologist in Charge of Laboratory of Plant Life History.

VEGETABLE PATHOLOGICAL AND PHYSIOLOGICAL INVESTIGATIONS.

Issued April 28, 1904.

WASHINGTON:

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1904.

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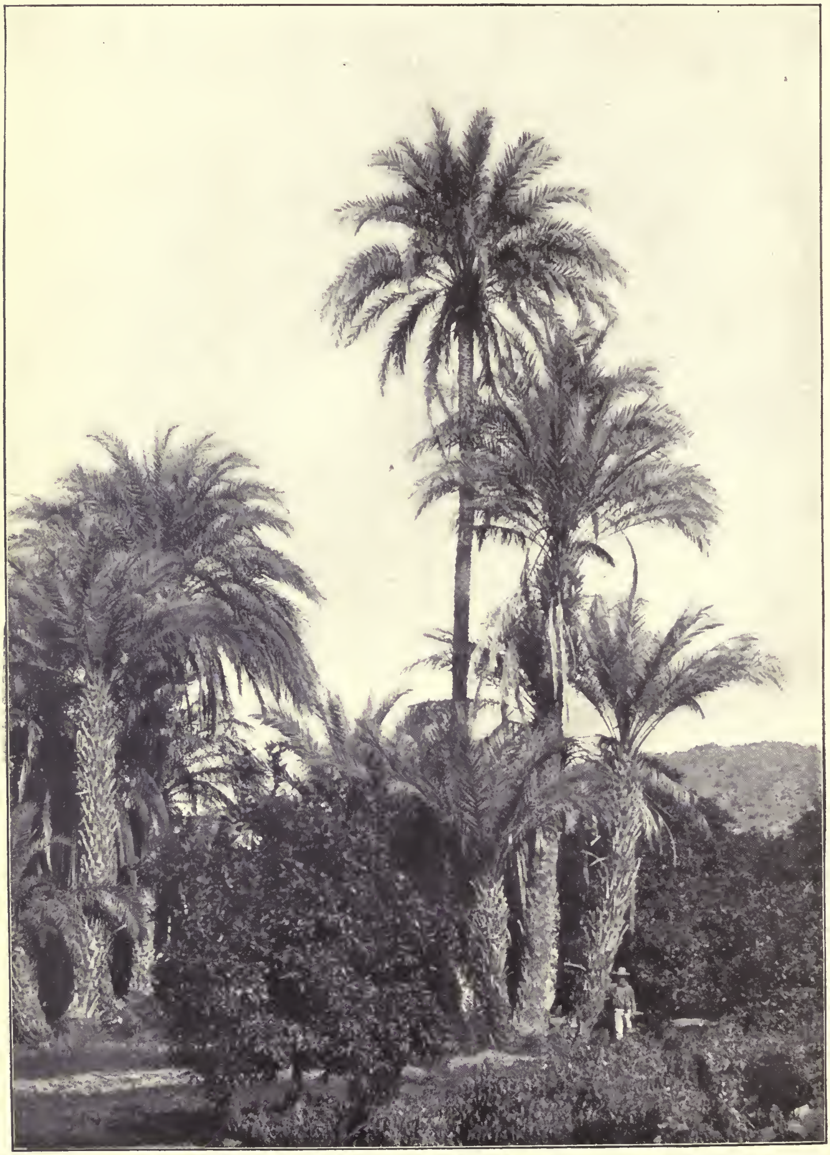

OLD DATE PALMS AT HERMOSILLO, NORTHERN MEXICO.

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BUREAU OF PLANT INDUSTRY.

B. T. GALLOWAY, *Chief.*

J. E. ROCKWELL, *Editor.*

VEGETABLE PATHOLOGICAL AND PHYSIOLOGICAL INVESTIGATIONS.

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[a] Detailed to the Bureau of Forestry.
[b] Detailed to Botanical Investigations and Experiments.

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LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF PLANT INDUSTRY,
OFFICE OF THE CHIEF,
Washington, D. C., September 15, 1903.

SIR: I have the honor to transmit herewith a paper entitled "The Date Palm and its Utilization in the Southwestern States," and recommend that it be published as Bulletin No. 53 of the series of this Bureau.

This paper was prepared by Mr. Walter T. Swingle, in charge of the plant life history work in the Office of Vegetable Pathological and Physiological Investigations, and was submitted by the Pathologist and Physiologist with a view to publication.

This Bulletin is the first of a series of life history studies of crop plants, treating the crop from every possible standpoint and bringing together all useful information regarding successful cultivation. The importance of such thorough study and complete treatment of the subject will be at once apparent. The illustrations, which comprise twenty-two full-page plates and ten text figures, are considered necessary to a full understanding of the text.

Respectfully,

B. T. GALLOWAY,
Chief of Bureau.

HON. JAMES WILSON,
Secretary of Agriculture.

PREFACE.

The following bulletin by Mr. Walter T. Swingle on the date palm embodies the results of an investigation of the climatic, soil, and cultural needs of this fruit tree, which he has had the opportunity to study both in the Sahara Desert and in our own Southwest.

It is shown that no heat is too great and no air too dry for this remarkable plant, which is actually favored by a rainless climate and by hot desert winds. It is also shown that the date palm can withstand great quantities of alkali in the soil—more than any other useful plant. This demonstration is of special interest now that water has been brought into the Salton Basin, or Colorado Desert, in southeastern California, rendering it possible to irrigate some hundreds of square miles of very rich land where the climate is probably even more favorable for the culture of the choicest sorts of dates than in the Sahara. Recent researches of the Bureau of Soils have shown that a large proportion—over half—of the soils in the irrigable part of the Salton Basin is too alkaline to support any ordinary crop. It is shown in this bulletin that the date palm can be grown without difficulty on four-fifths of the irrigable lands of this basin, and that on fully one-quarter of the area it is probably the only profitable crop plant that can succeed permanently. It will take considerable time, however, to bring the industry to a paying basis.

The date palm will be of prime importance in many other irrigated desert areas in the Southwest, where the alkalinity of the soil is too great to permit the culture of other crop plants. It is, moreover, confidently believed that date culture, far from being a last resort for lands unfit for anything else, is one of the most profitable fruit industries, and that it will pay to plant date palms on the best lands and give them the most careful attention.

The conditions for the proper utilization of the date palm in this country have been determined by means of a very careful study into its life history requirements. This bulletin will show clearly the importance of life history investigations, of which Mr. Swingle is in charge. Such investigations are being extended to other important crop plants.

The work covered by this report has been carried on in cooperation with the Office of Seed and Plant Introduction and Distribution, through which all of the important date importations have been made. The investigations relating to soil conditions have been carried on in cooperation with the Bureau of Soils.

ALBERT F. WOODS,
Pathologist and Physiologist.

OFFICE OF VEGETABLE PATHOLOGICAL
AND PHYSIOLOGICAL INVESTIGATIONS,
Washington, D. C., August 14, 1903.

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THE DATE PALM AND ITS UTILIZATION IN THE SOUTHWESTERN STATES.

INTRODUCTION.

The purpose of this bulletin is to call attention to the peculiar suitability of the date palm for cultivation in the hottest and most arid regions in the Southwestern States and to its remarkable ability to withstand large amounts of alkali in the soil. The most intense heat, the most excessive dryness of the air, the absence of all rainfall for months at a time during the growing season, and even the hot, dry winds that blow in desert regions are not drawbacks, as in almost all other cultures, but positive advantages to the date palm, enabling it to mature fruit of the highest excellence.

The growing of the best sorts of dates where the climate is favorable promises to be more profitable than any other fruit culture possible in such regions, and this industry would long ago have been carried on extensively had the climatic and soil requirements of this plant been better known, and had there not been general ignorance as to the methods of propagation, as well as a lack of the best sorts to propagate.

The date palm has the unusual power of resisting large amounts of alkali, the most dangerous foe to agriculture in the arid regions, both in the soil and in the irrigating water. This will permit it to be grown profitably on lands so salty as to prevent the culture of any other paying crop, and thereby render feasible the reclamation of hundreds of square miles of the most fertile lands in the Southwest which, at great expense, have been put under irrigation.

Thanks to the hearty cooperation of Prof. Milton Whitney, Chief of the Bureau of Soils, it has been possible to investigate thoroughly the ability of the date palm to withstand alkali in the soil. Samples of soils were selected by the writer in date plantations in the oases in several different regions in the Sahara Desert (see map, Pl. II, p. 76) with especial reference to a determination of the effect of alkali on the growth and fruitfulness of the date palm. Analyses of these soil samples, made by Mr. Atherton Seidell, were placed at the disposition of the writer by Professor Whitney, and have rendered it possible to

determine with some degree of accuracy the alkali resistance of this remarkable plant, which important point in its life history is here considered in detail for the first time.

One of the principal reasons for publishing this bulletin is the completion of a system of canals which will irrigate a considerable portion of the Salton Basin,[a] or Colorado Desert, in southeastern California, from the Colorado River, some 60 miles away. Water was first brought in, after great expense had been incurred and no inconsiderable engineering difficulties overcome, in June, 1891, and since then the development of the new country has been very rapid. Before the end of the year 1891 some 125,000 acres of this land had been taken up. This desert lies mostly below sea level and is characterized by having the hottest and driest climate known in North America.

As soon as water was put on it was evident that some of the land was alkaline, and researches made by the Bureau of Soils of the Department of Agriculture[b] have shown that over half the lands now irrigable are too salty to permit the culture of any but alkali-resistant plants. Probably one-fourth of these lands will not support permanently any other profitable crop than the date palm. Now, it happens that the climate of this desert is better adapted than that of any other region in North America for the culture of the best sorts of dates and is even better than that of the northern part of the Sahara Desert, whence are exported the choicest dates that now reach the markets of Europe and America. The advantages of this region over any others in the United States or Mexico for the growing of the best late varieties of dates, such as the Deglet Noor, are so great as to give it almost a natural monopoly of the production of these dates, the most expensive dried fruit on our markets.

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[a] In the United States the term "desert" is applied only to unirrigated or uncultivated arid regions, and as fast as such areas are reclaimed and put to profitable culture by means of irrigation they cease to be called deserts and receive some other name. The appellation "desert" is a hindrance to real-estate transactions and is felt to be unjust and opprobrious by those who live in the midst of flourishing fruit orchards and alfalfa fields. Doubtless the same change of name will take place in case of the Colorado Desert, and indeed the misleading term "Colorado delta" has already been applied to the newly irrigated lands about Imperial and Calexico. The true delta of the Colorado River lies to the southward, where this stream enters the Gulf of California. The region in question might very appropriately be called the Salton Basin, inasmuch as it is a true basin, an area surrounded on all sides by mountains or higher lands and depressed far below sea level in the center, where its most prominent topographical feature, Salton Lake or Salton Sink, is located. Throughout this bulletin Salton Basin is used instead of Colorado Desert to designate the lower parts of the lands sloping toward Salton Lake, a region limited on the north by the San Bernardino Mountains, on the west by the San Jacinto Mountains, and extending southward into Mexico to the line beyond which the delta lands slope toward the Gulf of California.

[b] Means, Thos. H., and Holmes, J. Garnett. Soil Survey around Imperial, Cal. Circular No. 9, Bureau of Soils, U. S. Dept. of Agriculture, 1901.

There exists, therefore, an unusual combination of circumstances, in that the opportunity for introducing a most profitable new industry into this region coincides with the pressing needs of a new country for some crop which can withstand alkali.

The resistance of the date palm to alkali is so much greater than that of other crop plants that it will be indispensable for the more alkaline areas through the Southwest wherever the climate is hot and dry enough to permit even the less valuable early sorts to mature. Already date palms are being planted on alkali lands in the Salt River Valley, Arizona, and as a result of the demonstration of the feasibility of growing them the price of such land has more than quadrupled within the last five years. Doubtless within a decade date culture will be much extended in Arizona, and it probably will become the most important fruit industry in the Salton Basin in California.

It becomes a matter of great importance to show what the climatic requirements of the date palm are and to determine how much alkali it can withstand, as well as to indicate how date palms are propagated and how their culture is carried on. This exposition is especially necessary in case of this plant, as its needs as to climate and soil are unlike those of any other plant commonly grown, and the methods followed in its propagation and culture are widely different from those employed for other crop plants.

It is believed that these data, here presented in detail,[a] will serve to facilitate the establishment and the extension of a new industry in this country.

WHAT IS THE DATE PALM?

The date palm was one of the first plants to be cultivated, and has been grown for at least four thousand years along the Euphrates and Tigris rivers. It has been for ages and is still the most important food plant of the great deserts of the Old World, and many regions in Arabia and in the Sahara would not be habitable were it not for this tree. Not only does it yield a delicious fruit of great food value, but it also furnishes in many regions the only timber suitable for use in the construction of houses and for making a thousand and one necessary objects. Its leaves furnish a partial shade, under which it is possible to cultivate other fruit trees which could not exist were they exposed to the direct rays of the sun and the burning winds in the desert; thousands of fig, almond, pomegranate, and peach trees and grapevines, forming veritable orchards, are cultivated in the palm-covered oases, especially in the northern Sahara. For centuries the transportation of dates has been the chief motive for the formation of the great

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[a] Many of the facts here presented were summarized by the writer in a previous article, entitled "The date palm and its culture," Yearbook of the Department of Agriculture, 1900, pp. 453–490; also reprinted.

caravan routes which run in every direction through the deserts in Africa and Arabia. The exportation of dates to Europe and to America is an important industry both in North Africa and in the countries bordering the Persian Gulf.

The value of the dates imported into the United States alone averaged for the ten years ended June 30, 1900, $402,762 per annum, as appraised at the exporting point, but the real value when received at the American port was doubtless 50 per cent greater, or $600,000 a year. This value is now exceeded only by the imports of two other dried fruits—Zante currants, $916,908 in 1900, and Smyrna figs, $513,895, in 1900. Inasmuch as California has been producing large quantities of second-class dried figs for some years, and since 1900 also Smyrna figs of the best quality,[a] it is likely that in the near future the value of the imports of figs will fall below that of dates, which will then rank second in value among imports of dried fruits.

The date palm, as its name indicates, belongs to the great family of palms. Like the majority of its relatives, it has but a single bud at the top of the trunk, and if this bud be destroyed the tree usually dies. The date palm, however, unlike the cocoanut palm and unlike the majority of palms, produces offshoots, or "suckers," at the base of the stem (see Pl. XVII, fig. 2, and Yearbook, 1900, Pl. LIX, fig. 4),[b] at least during the first decade of its existence. Old date palms which are in full bearing do not produce such offshoots, and if the terminal bud be destroyed the whole plant will die, since offshoots are very seldom, if ever, produced at the top of the trunk. The date palm, like most other members of this family, has a trunk which remains of the same diameter, no matter how old it may be, there

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[a] This gratifying result was brought about by the introduction of the fig insect (Blastophaga), which the writer accomplished in the spring of 1899 by sending from Algeria the winter galls of the male fig tree containing these insects. The Blastophaga fertilizes the flowers of the Smyrna type of figs, which, unlike ordinary figs, do not set fruit unless pollinated. The large orchard of Smyrna figs at Fresno, Cal., belonging to Mr. George C. Roeding, which had produced but a few dozen figs pollinated by hand during the twenty years it had been planted, began to yield abundant crops as a result of the introduction of this beneficent insect, and in 1901 produced some 70 tons of dried figs. The success of this orchard has led to a renewed interest in fig culture, and several other large plantations have been set out near Fresno, while many orchards of inferior varieties are being grafted to the Smyrna fig.

[b] Throughout this bulletin references have been made to plates published by the writer in his paper, "The date palm and its culture," in the Yearbook of the Department of Agriculture for 1900, pp. 453–490, Pls. LIV–LXII. This publication is accessible in all libraries, and it has been arranged to send a reprint of the paper with the present bulletin to all applicants in the Southwest who live in regions where date culture is feasible. This will render it possible for all interested to refer to the plates in this previous paper. In order to shorten the references to these plates they are cited as "Yearbook, 1900," with the number of the plate. Inasmuch as the plates of this Yearbook article were numbered from LIV to LXII and those of the present bulletin are numbered from I to XXII, confusion is impossible.

being no secondary increase in diameter with increasing age such as occurs in ordinary fruit and forest trees. In consequence, the age of a palm tree can be roughly estimated from its height, but never from the diameter, nor, as is customary among woodsmen, by counting the rings of annual growth, for the simple reason that the date palm has no such rings.

The leaves of the date palm (frontispiece and fig. 1, p. 16) are feather shaped and very large, frequently from 12 to 18 feet long. The ancient Egyptians had a tradition, held also by some tribes of modern Arabs, that the date palm produces twelve leaves in a year. It is an interesting fact that the Egyptian hieroglyphic which signified a month represented a single leaf of the date palm, and the sign for a year pictured a crown of leaves of the date palm.[a] Of course, there is no such fixed interval of time between the unfolding of successive leaves, but it is true that the date palm usually produces from twelve to twenty leaves in a year.

These leaves remain alive and green for several years, but finally lose their color and bend downward toward the trunk. (See the lower leaves on the tall palm in Pl. XIX, fig. 2.) Travelers who have seen date palms growing remote from human habitations in the Sahara Desert report that in such situations the old leaves remain attached to the trunk permanently, the palm being crowned with living green leaves and the trunk clothed to the ground by the reflexed dead leaves. Furthermore, in such conditions, where the date palm is left to grow uncontrolled by man, the offshoots produced by the young palms grow unhindered and often rival in size the parent trunk, and they in turn give rise to other offshoots, even after the parent stem has passed the age when it would produce offshoots. The result of this is that instead of a single palm tree, the traveler sees a great thicket composed of a few tall trunks (the original palm and the oldest offshoots), surrounded at the base by a tangled mass of younger offshoots, struggling upward and outward. Such a clump is shown in Yearbook, 1900 (Pl. LIX, fig. 4). All of these trunks retain their dead leaves permanently, so that such a clump of palm shoots is well nigh impenetrable. To those who have traveled in countries where the date palm is the commonest cultivated tree, the description given above will seem very strange. In all such countries the date palm is well cared for and the dead leaves removed, leaving a clean trunk, crowned with a tuft of living leaves. (See frontispiece and Yearbook, 1900, Pl. LX.) Besides this, the Arab cultivators are careful to remove the offshoots as soon as they are large enough to plant, or to destroy them when young in case they do not desire to propagate the variety. Such

[a] Fischer, Th. Die Dattelpalme, Ergänzungsheft No. 64. In Petermann's Mittheilungen. Gotha, 1881, p. 4.

offshoots, ready to remove, are shown on Plate XVII, figure 2, and offshoots removed and ready to transplant on Plate VI, figure 3.

Unlike most fruit trees, the date palm has the male and the female flower on separate individuals. If grown from seed, about half of the resulting palms are male and about half female. If such trees be allowed to grow to maturity in this proportion enough pollen is blown by the wind to fertilize all the flowers properly. It would be, however, a very expensive method of culture to irrigate and cultivate such a large proportion of male trees. The Arabs—and before them the

FIG. 1.—A young Deglet Noor date palm at Biskra, Algeria; below a flower cluster just opening; above two young fruit clusters, the larger still bound about with the cord used to attach the mal flowers in pollinating. May, 1900. (After negative by the writer.)

Assyrians—learned to pollinate the palm artificially, and from a smal proportion of male trees to fertilize the flowers of a very great numbe of female trees. At the present time the proportion followed in commercial planting is that of about one male tree to a hundred femal trees.

The date palm blooms in the early spring, producing from six to twenty flower clusters, according to the age and vigor of the tree (see fig. 1). Each flower cluster on the female tree produces a bunch o

dates, consisting of numerous fruits, borne on slender twigs, which branch from a main stalk (Pl. XXII and Yearbook, 1900, Pl. LX). Such a bunch may bear from 10 to 40 pounds of dates, and a vigorous tree is commonly allowed to produce from eight to twelve such bunches. The date itself is, of course, familiar to everyone; it is an oval fruit from 1 to 3 inches long, and one-half or one-third as wide, containing a single seed surrounded by a half dry and very sweet pulp, usually amber colored. There are very many varieties of dates, differing widely as to character and quality, as will be explained more in detail farther on.

DATE CULTURE BY THE ANCIENTS.

The date palm is one of the oldest cultivated plants. It is fully described on the clay tablets of the ancient Assyrians. It was undoubtedly one of their most important food plants, and every detail of its culture, the operation of pollinating the flowers, and even the serving of the fruit at the tables of the wealthy were delineated with great accuracy on their monuments and wall sculptures. It is probable that the date palm was first extensively grown in the valleys of the Euphrates and Tigris rivers. It was apparently little known and but slightly esteemed in ancient Egypt before 3000 B. C., although as early as 2000 B. C. it had already become a well-known fruit tree. Not much is known as to the origin of the date palm, although everything points to its being native in some of the ravines bordering the deserts of northern Africa or Arabia. It is probable that it was first cultivated by the Assyrians, afterwards by the Egyptians, and that very early its culture became almost a national industry with the Arabs. It is true that the date palm existed in ancient Africa before the arrival of the Arabs. It was, however, comparatively unimportant, at least in the western Sahara, and the varieties were probably inferior. When the Arabs invaded the western Sahara and the Barbary States during the seventh century, and at various intervals until the twelfth century, they introduced the use of the camel and thereby rendered it possible for the inhabitants of the oases to satisfy all their wants, simply by growing an abundance of dates, since the camels could carry the dates to the more fertile regions bordering the Mediterranean, where they could be exchanged for the wheat and barley needed in the Sahara for making bread. In consequence of this economic revolution, the culture of the date palm speedily became, and is still, the most important interest throughout the Sahara Desert.

The Moors undoubtedly introduced the date palm into Spain, where, in spite of the unfavorable climate, it was extensively planted during the Saracen domination. The first date palms in the New World were grown from seeds carried from Spain by the missionaries who accompanied the Spaniards on their voyages of discovery and conquest.

PROPAGATION OF THE DATE PALM.

SEEDLING PALMS.

Date palms may be grown from seed and are generally so grown in Mexico and in India, but if so propagated something over half the palms are males, which produce no fruit whatever, while of the remaining female plants probably, on the average, not more than one in ten produces good fruit. This would mean that in planting 100 seeds, on the average only four or five palms bearing good dates would be secured and probably as many more of second quality, or in all some 10 per cent of the number planted would yield edible fruit. It should be said that in Arizona, and even in Mexico, very many of the seedling sorts do not reach maturity because of the insufficient summer heat; but if grown in the Salton Basin, where all the sorts could mature, a larger proportion, possibly 15 per cent, would produce fruit that could be used.

SEEDLING DATE PALMS FOR THE SALTON BASIN.

In view of the scarcity of offshoots of the best varieties and the pressing need for date palms for many parts of the Salton Basin, it would be well worth while to plant orchards of seedlings, and when they are in bearing the worthless sorts could be cut out and their places gradually filled by taking offshoots from the seedlings yielding good fruit. It would be possible to begin thinning out the excess of males as soon as the flowers begin to show, some four to six years after planting. The trees could be planted, say, 12½ feet apart, in rows 25 feet apart, giving about twice the number that should be left, because nearly half the total number will prove to be males, to be cut away as soon as recognized. By the sixth or seventh year after planting the quality of the fruit produced by the female plants could be judged and the plants producing the poorest dates could be removed and replaced by offshoots from the best seedlings, which should, of course, be planted where the rows show the largest gaps, resulting from the removal of superfluous males and worthless females. In the course of a few years it would be possible to remove all the less valuable seedlings and replace them with the better sorts. This process could go on indefinitely by continually replacing poorer sorts with better as fast as offshoots were available, until only two or three of the best sorts remained. No outlay would be entailed for offshoots, and if considerable numbers of seedlings were grown from the best dates there certainly would be some sorts of value among them.

If any attempt be made to start seedling date orchards in the Salton Basin it should be borne in mind that the young seedling can not withstand nearly as much alkali as can offshoots or old palms. Prof. R. H. Forbes [a] finds that many of the young plants grown from seeds which

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[a] Oral communication to the writer, 1902.

had been planted at the Cooperative Date Garden at Tempe, Ariz., were killed by alkali shortly after they appeared, while the offshoots growing near by were unharmed. In case alkaline areas are to be planted it would be best to establish a nursery on alkali-free land and transplant the seedlings when they are 1 or 2 years old, or, if the soil is very alkaline, when 3 or 4 years old, to the positions they are to occupy permanently. Where the palms are to be planted on the very worst alkaline lands it would be well to allow the young date palms to flower in the nursery rows, so that the males could be discarded and only females set out, with the precautions for washing out the alkali mentioned below, thus avoiding the expense and trouble of caring for the worthless male plants. It is easy to distinguish the male from the female plants by an inspection of the flowers, which, as is shown in Plate VII, figure 3, are very different in the two sexes. In transplanting young seedlings the leaves should be cut back severely to correspond with the cutting back suffered by the root system.

It is interesting to note in this connection that the date palm requires for its germination not only fresh water, free from any considerable amount of dissolved alkali, but also a large and continuous supply of such water. The young seedling shows curiously enough a whole set of peculiarities of structure which enable it to throw off an excess of moisture. Fritsch, an Austrian botanist, concluded that the seed was adapted for germination during the rainy season, and that it was meant to grow in earth thoroughly saturated with water.[a] Not only are the roots devoid of hairs, resembling in this peculiarity those of plants which grow in swamps and in water, but they have numerous aerating canals, and in other ways show adaptation for growth in very moist situations. There are even pores at the tops of the leaves by which the little seedlings can get rid of superfluous moisture which has been absorbed by the roots.

Seedling dates are nearly always found along irrigating canals or in situations where the earth is kept constantly moist. These are strong indications of the natural habitat of the date palm, which should be expected to grow where the earth is very moist, at least during the rainy season. It is practically impossible for date seedlings to start in unirrigated arid situations, even where cacti and other desert plants grow abundantly.

As is clear from what has been said, the date does not reproduce true to type from seed. This may be in part because no attention has been paid to the pedigree of the male plants used to furnish pollen, so that even the choicest dates may have been pollinated from males of the most worthless character. If it should be found desirable to plant seedling orchards it would be well to arrange to have Deglet Noor

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[a] Fritsch, G. Anatomisch-physiologische Untersuchungen über die Keimung der Dattelpalme, in Sitzungsb. d. k. Akad. d. Wiss. Wien, Bd. 93, Abth. I, April, 1886.

dates pollinated from a number of trees in the hope that some of these males would produce seedlings of a superior type. If possible males known to be seedlings of the Deglet Noor or of some other superior sort should be employed in such pollination. It is worthy of note that the male dates in California, and especially those in the Salt River Valley, Arizona, are for the most part the offspring of fairly good soft dates, probably from the Persian Gulf region, purchased in the markets. So Arizona and California dates would be well worth planting, since both parents of the seeds in such dates are the offspring of soft dates, whereas in most regions where the date palm is grown the males are likely to be the product of dry dates (for most of the dates in those countries are of the dry type) dropped by chance in a wet spot where they could grow.

The seedlings of a single sort of date may present the most remarkable variations, and usually the parent type is not exactly reproduced by any of the offspring. This is clearly shown by the experiments of Col. Sam Taylor, of Winters, Cal., who tried to propagate from seed the valuable early ripening Wolfskill date growing on his place. This was done because this palm had ceased to produce offshoots before its value was recognized. Many of these seedling dates have fruited, but none resembles in the slightest degree the parent variety; most of them are much later and consequently fail to mature at Winters, where the summer heat is insufficient to ripen any but the earliest sorts.

PROPAGATION OF THE DATE PALM BY OFFSHOOTS.

In all regions where its culture is an important industry the date palm is almost invariably propagated by removing and planting the offshoots or suckers which spring up around the base of the trunk (Pl. XVII, fig. 2, and Yearbook, 1900, Pl. LIX, fig. 4). These offshoots reproduce the parent variety exactly and have the great advantage of coming into bearing sooner than seedlings. Offshoots are produced abundantly by young date palms, but cease to form when the trees reach the age of 10 to 15 years. Usually three or four are left attached to the parent plant, any in excess of this number being cut away as fast as they form. One offshoot can be removed every year until they cease to be produced. They are cut away from the parent trunk when they are from 3 to 6 years old, after they have begun to develop roots, if as usual they start from below the surface of the ground and have their bases covered with earth. The leaves are all cut away, leaving only the bud in the center protected by the leaf-stalks (Pl. VI, fig. 3). No roots are left attached to the offshoot, which, when so reduced to a mere stump, can stand much exposure. Some offshoots procured by the writer on May 18 and 19, 1900, at Ourlana, Algeria, in the Sahara Desert, were shipped by camel-back

(Pl. VI, fig. 2) to Biskra, 95 miles away, and from there to Algiers, some 390 miles by rail, with no packing except a little palm fiber about the bases. One box of these offshoots was packed in straw with no moisture whatever except from having been wet twice; once at Biskra and once at Algiers. So packed they were sent to New York by steamer, arriving July 3, then transshipped to New Orleans and finally carried by rail from New Orleans to Tempe, Ariz., where they arrived July 17. They were unpacked July 20, two months after they had been dug up. Prof. R. H. Forbes, under whose personal supervision the palms were planted and cared for, reports that the box of offshoots which had no packing other than the loose dry straw came through as well as those packed in damp moss or in charcoal. Some 80 per cent of these suckers lived.[a]

It is very important that the offshoot be planted out high enough so that the growing bud in the center is never in danger of being covered with water when irrigated. (See fig. 6, p. 42.)

In order to force the offshoots to take root and grow, the chief requisite is that the ground be kept constantly wet about their bases. If the young plants dry out once they are lost, for the delicate new roots that are just forming will be killed. The Arabs water the offshoots every day for the first forty days after planting and then twice a week until winter, after which they are watered as often as may be necessary to keep the ground thoroughly moist.

Another requisite almost as important as the keeping of the base of the plant moist while roots are starting is that the ground be warm when the offshoots are transplanted. It is useless to set out offshoots in autumn or winter; the best season is late in spring or early in summer, when the ground is thoroughly warm and when there is a long hot season after planting, permitting the young palms to become well established before winter. It is not necessary to shade the young offshoots, but they should be protected against cold during the first winter after being set out, by wrapping with burlap, heavy paper, or straw.

Professor Forbes finds (see p. 19) that young seedlings are often killed by alkali where offshoots and old palms grow all right. Strong alkali is probably injurious also to offshoots just striking root, and the following method of preventing the rise of alkali, communicated by Professor Forbes, may be advantageously followed in all cases where there is danger to be apprehended from this source: Throw up a high border on each side of the rows, running in both directions, thus creating a square inclosed space about each palm. This space may be flooded from the irrigating canals with fresh water, which carries away the salts accumulated near the surface down to

[a] Forbes, R. H. Twelfth Annual Report, Arizona Experiment Station, p. 317.

lower level beyond the reach of the young roots. The area about the offshoot inclosed by the borders should then be covered with straw to a depth of a foot. This mulch will hinder evaporation and thereby restrict the rise of alkali, since each application of water washes the alkali down anew and the mulch continues to act as a check on evaporation. Such a method of planting should be adopted in those parts of the Salton Basin where there is danger of a rise of alkali from the subsoil.

DISTANCES BETWEEN TREES.

The Arabs almost invariably plant the date palm without any attempt at placing the young offshoots in definite order. The result is, it is almost impossible for them to be sure of planting the trees at any constant distance from each other, some being close together, others wide apart, as can be seen in Plates XII and XIII.

The unsystematic and frequently careless methods employed by the Arabs in the culture of the date palm can not be taken as models to be followed in introducing the date industry into the Southwest; we should rather follow the example of the French colonists in the Sahara, who plant the date palm in regular rows (see Pl. XVII, fig. 1), and have, as a rule, definitely planned and carefully executed systems of irrigation and drainage. Although the Arabs plant the date palms very close together, the French have found it advisable to place the trees wide apart, and many of the French colonists regret having placed the trees only 20 or 22 feet apart, their opinion now being that date palms should be planted from 26 to 33 feet from each other.

Ben Chabat, an Arab, who is considered an authority on date culture, makes two date palms speak together; one says to the other, "Take thy shadow away from mine and I will produce alone for us two together"[a]—expressing the idea that too close planting is dangerous. At 26 feet apart, which may be taken as an average distance, about 60 palms would be planted on an acre. If the palms are put 30 feet or more apart other crops can be grown between the trees even when old.

The amount of irrigation water available during the hot season and the value of land are factors which must be considered in deciding at what distance the offshoots should be planted. In general the farther apart the palms are, the more heat and light each receives, and the better and the more abundant is their fruit.

Even when planted 26 feet apart or less there are, of course, large strips which lie unused between the palm trees for the first ten or twelve years after planting. It has become a common practice in the Algerian Sahara, copying to some extent after the Arabs, to plant garden or field crops between the trees until the palm trees become large enough to shade the ground. In case the soil is alkaline, it is

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[a] Masselot, F. Bul. Direction Agric. et Comm., Tunis, vol. 6 (1891), No. 19, p. 128.

frequently impossible to grow any crop until two or three years of abundant irrigation, coupled with a good system of drainage, have washed the alkali out of at least the top layers of the soil. Barley is usually the first crop grown on alkaline soil. After barley has been grown a year or two, the abundant irrigation being, of course, kept up, the land usually becomes freed from alkali sufficiently to permit horse beans, cowpeas, beets, and other garden crops, and, what is of more importance, alfalfa, to be grown. This Saharan alfalfa (see Pl. XVI, fig. 2), although refusing to grow on soil which produces a fair crop of barley, is, nevertheless, able to withstand without injury a percentage of alkali in the soil which would prevent the growth of ordinary alfalfa.[a]

PROPORTION OF MALE TREES THAT SHOULD BE PLANTED.

It has been found in the date plantations of the Sahara that for every hundred date palms there should be at least one male tree to furnish pollen for use in fertilizing the flower clusters in spring. There is already a large number of male date palms in Arizona and California, so that it has not been thought necessary to introduce more than a very few from the Old World. The ratio of one male for every hundred female palms applies only in the Sahara, where it is possible to secure male palms known to flower at the right time to be used in pollinating. It often happens that many of the seedling male plants flower too late to be of any use.[b] It does not interfere so much with the usefulness of a male date palm to have it bloom too early, since the bunch of male flowers can be preserved for some weeks without serious deterioration. In view of these facts it will be advisable in starting any plantations to put out at least one male palm for every fifty females, or better, one male for every twenty-five females. It will be desirable also to secure offshoots from different male trees in order to avoid getting male trees all of one kind, which might be found to bloom at the wrong season. In case no offshoots of male trees can be secured, a few seeds may be planted and the male palms saved to furnish pollen. When the trees begin to flower it will be possible to see readily which male trees flower at the right season; the others can be destroyed and offshoots from female trees planted in their places.

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[a] After much correspondence with the Arab caids in the interior of the Sahara, a small quantity of the seed of this valuable alfalfa was obtained for the writer in the spring of 1901. It is earlier than ordinary alfalfa and resists heat and alkali better. It has been planted in the Cooperative Date Garden at Tempe, Ariz., and it is hoped that it will prove as valuable in the Southwest as it is in the Sahara.

[b] Out of six date palms which had flowered up to 1898 at the San Joaquin Valley substation of the California Experiment Station, three were female and three male, but two of the male palms did not flower until the female trees had ceased blooming.

VARIETIES OF MALE DATE PALMS.

Some male trees produce more pollen than others, and are much preferable to use in pollinating. When once good sorts of males are found they should be propagated by offshoots in the same manner as the female plants. In most parts of the Algerian Sahara no particular attention is paid to the propagation of suitable male palms, and in consequence pollen is sometimes scarce early in the flowering season and again later on, which often renders it necessary to procure pollen from neighboring orchards or even from other oases, sometimes at considerable trouble and expense. In Tunis there is a male variety propagated by offshoots called the Deglaoui used to pollinate late-blooming sorts. Another called the Dakar majahel was secured by Mr. D. G. Fairchild in Egypt, and has been sent to the Cooperative Date Garden at Tempe, Ariz. It is said to be the only male palm which produces pollen at the right time to be used on all of the eight varieties of female dates grown about Ramley, Egypt.

The chief requisite of a male date palm is that it shall produce an abundance of pollen at the right time to be used in pollinating the female sorts that are grown. If date palms were propagated from seed, and still more if any attempt should be made to breed new and better sorts, it would be very desirable to secure male sorts capable of transmitting desirable characteristics to their offspring. (See p. 20.)

Schweinfurth has recently put forth the claim[a] that the male sort used for pollinating the flowers has a decided influence on the shape and, what is more important, on the size of the seed of the dates which result. If this were true it would be very important to secure male sorts which when used for pollination would produce small seeds. Schweinfurth's supposition is, however, without doubt erroneous, for in spite of his assertion that the observed variability of the seed in dates of the same variety[b] is a proof of the effect of the different sorts of pollen used to fertilize the flowers, the fact is that the seeds of any one sort are so uniform in size and shape as to furnish good characters for use in distinguishing varieties, and are regularly so employed by both Europeans and Arabs. The only part of the seed which could be affected directly by the male parent is the embryo, which in the date occupies so small a fraction of the bulk of the seed that it is not surprising that there is no observable effect of the pollen on the seed and much less on the pulp which surrounds it.

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[a] Schweinfurth, Dr. Georg. Ueber die Kultur der Dattelpalme. In Gartenflora, vol. 50, 1901, p. 513.

[b] Naturally the seeds are not all exactly alike, even on the same tree, and some varieties of dates have seeds which vary appreciably in shape and even in size; but this range of variation is itself a varietal character. Of course the incorrect identifications of dates often made offhand by the Arabs may easily lead to erroneous ideas as to the extent of variation in a sort through a confusion of varieties similar in external appearance, but differing in seed characters.

Male date palms generally have stouter trunks and more leafy crowns than female trees (see Pl. V, fig. 2), and some have said that even the young plants could be distinguished—a matter of much importance where dates are propagated from seed, when it is desirable to recognize and destroy as soon as possible the superfluous male plants. It has not been found possible to depend on any of the signs given for distinguishing young male plants, and they can be recognized with certainty only when they are in flower. An inspection of figure 3 on Plate VII will show how different the male flowers are from the female and render it easy to determine the sex of the palms as soon as they show flowers.

CARE TO BE GIVEN DATE PALMS.

The chief care required by date palms is that they be irrigated as often as needful. The soil should be kept in a proper state of tilth, which is usually done by growing some crop between the rows, especially when the palms are young. The leaves are trimmed off as they die, and care is taken not to allow too many offshoots to grow at the base of the stem, for they draw on the strength of the parent plant. In general not more than three or four offshoots should be allowed to grow at once. At least one should always be left attached to the mother plant to be used to replace it in case of accident.[a]

Old palms, ten to fifteen years after planting, which have developed a good trunk 4 to 10 feet high, do not produce offshoots, and such trees require no attention other than the cutting away of the dead leaves, the pollination of the flowers, and the gathering of the fruit.

THE AGE AT WHICH DATE PALMS BEGIN BEARING.

The age at which palms come into bearing depends much upon the climate and soil; where planted in rich soil, watered abundantly, and where the summer heat is intense and long continued, the date may begin to fruit when very young. Trees have been known to bear in Arizona within four years after the seed was planted; however, such palms are too small to bear more than a very few fruits, and seedling trees are generally considered not to yield paying quantities of fruit until they are at least 6 or 8 years old (see Yearbook, 1900, Pl. LVII, fig. 1). When date culture is practiced scientifically, practically no seedlings are grown, but instead orchards are started by planting fairly large offshoots, which soon strike root, and which often bear

[a] Many valuable seedling dates have been lost in this country because the suckers were kept closely trimmed off until the trees were in bearing. Only then was their value discovered after it was too late to propagate them. If an offshoot is always left attached at the base of the palm it may in turn be allowed to produce suckers after the parent plant ceases to produce them, and in this way a continuous supply of offshoots may be produced even at the base of old palms, and no variety need be lost.

abundantly four or five years after being transplanted (see Pl. XXII). However, in the large plantations made in Algeria by the French colonists it is not considered advisable to allow the palms grown from offshoots to bear fruit until five or six years after they are set out, and the trees are not in full bearing until eight or ten years after they are planted. They continue bearing, if well cared for, until they are a hundred years or more old, a good tree producing an average of from 60 to 200 pounds of fruit a year,[a] although some trees have been known to produce as much as 400 or 600 pounds[b] when grown in rich soil and abundantly irrigated. The tree shown in a previous paper (Yearbook, 1900, Pl. LVII, fig. 1) is a demonstration of the capabilities of Arizona as a date-producing country. It was only 8 years old from the seed when photographed, and yet bore some 400 pounds of dates. Again, an Amreeyah palm, grown from an offshoot imported by the Department of Agriculture from Egypt in 1889, yielded in 1900 over 300 pounds of dates (see Yearbook, 1900, Pl. LXII, fig. 1). A little palm growing on the grounds of the University of Arizona, at Tucson, where the winters are often cold, bore, nevertheless, when it had been transplanted five years, two bunches of fruit weighing together some 30 pounds (see Yearbook, 1900, Pl. LVII, fig. 2). The large Deglet Noor palm growing at Biskra, Algeria, shown in the foreground of Plate LX, Yearbook, 1900, bore over 15 bunches of fruit, and the young Deglet Noor palm shown in Plate XXII, grown from a sucker set out only three years before, bore 3 bunches of fruit.

POLLINATION OF THE DATE PALM.

In a wild state the date palm is undoubtedly pollinated by the wind, and about one-half of the trees are males. It is probable that pollination would be incomplete unless the proportion of male trees was something like one-half, for, although enormous quantities of pollen are produced, only a very small part of wind-blown pollen ever reaches the female flowers. The artificial pollination of the date palm was doubtless discovered by the ancient Assyrians, and has been practiced probably for three or four thousand years at least. Because of the great economy of pollen brought about by this practice, one male tree suffices to pollinate from fifty to a hundred females.

The male flower cluster of the date palm consists of a stalk bearing

[a] M. Masselot has published a list of all the important varieties of dates grown in the Tunisian Sahara (Bul. Direc. Agric. et Comm., Tunis, Vol. 6, No. 19, Apr., 1901), and gives the average yield per tree of 92 sorts. The Loozee variety has the lowest average yield, 55 pounds, and the Areshtee and Hamraya the highest, 220 pounds; the average yield of all the 92 varieties is 116.5 pounds per tree.

[b] In the oasis of Tebbes, the northernmost in Persia, it is reported that a full-grown tree may yield 200 man (of 3½ pounds). Bunge, Petermann's Mittheilungen, 1860, p. 214.

a considerable number of short twigs to which the flowers are attached, the whole contained in a sheath at first entirely closed, but which finally ruptures, disclosing the flowers. (Pl. VII, figs. 1 and 3.) The Arabs cut the male flower clusters from the trees shortly before the flowers have fully opened, at a somewhat earlier stage than shown in Plate VII, fig. 1. The separate twigs to which the male flowers are attached (Pl. VII, fig. 3, twig below) are from 4 to 6 inches long, and bear anywhere from 20 to 50 male flowers, each containing 6 anthers full of pollen. One of these twigs suffices to pollinate a whole female flower cluster, and to bring about the development of a bunch of dates.

The female flowers, like the male, are borne inside of sheaths which are at first entirely closed. Finally the sheath is split open by the growth of the flowers within (Pl. VII, fig. 2, twig to left), and at this stage pollination is accomplished. The two tips of the cracked-open sheath are separated and the cluster of female flowers pulled out. (Pl. VIII, fig. 3.) A twig of male flowers is then inserted into the cluster of female flowers and tied in place with a bit of palm leaf or with a string. (Fig. 2 and Pl. VIII, fig. 4.) This completes the operation of pollination. The fruit cluster soon begins to grow rapidly, and in a few weeks the piece of palm fiber or thread with which the male flowers are held in place is broken by the pressure of the growing fruit cluster. Such a fruit cluster, still confined, but which will shortly break the fiber, is shown in figure 1 (p. 16).

Fig. 2.—Date flower cluster after artificial pollination; a sprig of male flowers has been inserted among the female flowers and tied fast with a palm-leaf fiber. (One-third natural size.) From negative by the author.

In the Algerian Sahara the date begins to flower in April, and sometimes produces flower clusters as late as June 1. The female flower clusters, which may be from five to twenty in number on a single tree, are not all produced at the same time. It is necessary in consequence to pollinate each flower cluster as it appears, and sometimes an interval of several weeks elapses between the appearance of the first and last flower clusters, so the trees must be ascended several times. The Arabs are very expert in doing this work and seldom overlook a tree, even where the palms are planted without any order; indeed, they rarely miss even a single flower cluster. It requires some skill to climb a tall palm tree, as

the trunk below is very smooth and it is difficult to pass between the stalks of the lower leaves in order to get at the flowers, since these leafstalks are armed with sharp, rigid thorns. (Fig. 1, p. 16.) The Algerians use no rope or other apparatus to ascend the trees, but climb up with their bare hands and feet. (Pl. VIII, figs. 1 and 2, and Pl. XIII.)

When date culture becomes an important industry in the Southwestern States it is probable that American ingenuity will devise methods of simplifying the work of pollination. For example, it would be easy to find means of marking the trees, and also the flower clusters, to show which have been pollinated. It might be possible, for instance, to tie the male flowers in place with a bright-colored strip of cloth, which would make it easy to see whether all the flower clusters had been pollinated or not. It is possible that in some places Indians will be able to take the place of the Arabs and do this work efficiently. It is absolutely necessary to pollinate all the flowers in order to secure dates of a good quality, although the dates do not fall off even if the flowers are not pollinated.

About the end of June, by which time the fruits are of some size, three fruits will have developed from each flower. Then occurs a remarkable phenomenon. If the flowers have been pollinated, two of the three fruits fall, leaving a single date for each flower. If, on the contrary, the flowers have not been pollinated, all three dates remain attached and continue to grow, becoming closely crowded together and somewhat deformed. Such dates are without seeds, but never properly mature, and are entirely valueless.[a] This peculiar behavior of the date palm enables the cultivator to tell by inspection which bunches have been pollinated and which have escaped attention, and the cutting away of the excess of bunches from too heavily laden trees should be postponed until this time, when it is possible to tell which bunches will mature perfect fruit. As a rule, only one or two clusters should be left on the young date palms which have just begun to bear, and only eight or ten even on old trees. Some varieties do not require much thinning, as they do not produce more bunches than they can nourish properly, whereas other sorts produce twice as many as the tree can support.

It sometimes happens that some of the female flowers appear in spring before any of the male trees have blossomed. To provide a supply of pollen for such flowers the Arabs make a practice of keeping a few bunches of male flowers from the previous year, which are placed in tight paper bags and hung up in a cool, dry place. The pollen is said to keep without deterioration for at least two years. The importance of securing male trees which flower at the right time has been noted on page 24.

[a] Such unpollinated dates have sometimes been supposed by inexperienced observers to be a superior variety because of their seedlessness.

By an inspection of Plate VII, figure 3, it will be easy for those who possess seedling date palms to determine the sex of the plant as soon as any flowers are formed. Superfluous male trees can then be destroyed and replaced by female trees before they have reached a large size. In case of gardens where there are a few female date palms and no males available to furnish pollen, it will be necessary to secure pollen from a distance—not a difficult matter, since male flowers can be shipped anywhere without deterioration if protected against loss of pollen.

After irrigation the labor of artificial pollination is the most important required in a date orchard. The irrigation, however, is very nearly such as would be given to any fruit trees, whereas the process of pollination is one that is not required by any other commonly cultivated tree. It should, however, be remembered that for the first ten or fifteen years after date palms are planted the flowers are so near to the ground that artificial pollination is performed very easily. The operation becomes difficult only when the palms are old and very tall.

GATHERING, CURING, AND PACKING DATES.

Some varieties of dates require practically no curing, being ready to pack and ship as soon as they have ripened. Other varieties, however, require some preparatory treatment. Dates are borne in bunches, which have a single stem with numerous slender twigs to which the fruits are attached. (Pls. IX and XXII.) A bunch carries from 10 to 40 pounds. It is very rare that all the dates on a bunch ripen at once, and in the case of choice varieties those which first ripen are frequently hand picked and shipped at once in order to get the high prices paid for the earliest shipments. It is also asserted that picking the outer dates of the bunch, which usually ripen first, permits the inner fruit to ripen better. Usually the whole bunch is cut off and hung up in a dry and shady place when most of these dates are ripe and the remainder beginning to ripen. It has been found necessary to remove any dates which have begun to spoil before the bunches are hung up, for if such dates are left the whole bunch may spoil. Usually within a week or two all of the dates ripen,[a] and the bunch is ready for shipment.

The choice varieties of dates are shipped from the Sahara either in bags or more often in long wooden boxes. They are afterwards

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[a] In case the dates do not mature because of an exceptionally cool summer, or in regions where the summer heat is inadequate, they can be ripened artificially after being picked by exposing them to the sun during the hot part of the day spread out on blankets, and storing them indoors at night wrapped up in the blankets on which they have been exposed during the day. Mr. Hall Hanlon, near Yuma, Ariz., often ripens considerable quantities of dates in this manner, which is that followed in northwestern Mexico (see p. 135).

repacked in smaller boxes, holding from two-thirds of a pound to 10 pounds. (Fig. 5, p. 34, and Pl. X.) The methods above outlined apply to the Deglet Noor, which is the variety chiefly exported from Algeria and Tunis to Europe. Other varieties, such as the Rhars, which are full of sugary juice when ripe, are not so easily handled. The Arabs usually hang up the bunches and allow the juice to drain off into jars. This juice, which they call date honey, is preserved and used, and the fruit, when it has become somewhat dry, is then packed in boxes or more often in skins. Dates of this class are usually packed tightly, and may keep for many years without deteriorating. Somewhat the same style of packing is practiced at Bassorah and Maskat in Arabia, whence come most of the dates received in American markets. There the dates are packed tightly in layers in wooden boxes for export to America and Europe. The dates containing an abundance of sugary juice have the disadvantage of being sticky when unpacked, and are not suitable to serve as a dessert fruit. As before mentioned, the Deglet Noor does not have this drawback if properly handled. It has, however, the defect of drying rather rapidly, and from the very fact that it is not tightly packed in boxes it doubtless dries all the quicker. With reasonable care, however, it can be kept for some months in a cool, dry, well-ventilated storeroom, and probably no other dried fruit having a value comparable to the Deglet Noor date can be put on the market with so little labor or at so little risk of loss. Practically the only hand labor required is that of arranging the dates in layers in the smaller boxes in which they are sent to the retail trade.

TYPES OF DATES AND VARIETIES SUITABLE FOR CULTURE IN THE UNITED STATES.

THE THREE TYPES OF DATES.

Of the three principal types of dates cultivated by the Arabs, only one is exported to Europe and America. This comprises the dates, so familiar to us, called by the Arabs "soft dates." They contain sometimes as much as 60 per cent of their weight of sugar, and are, in fact, candied on the tree, being preserved from decay by the enormous amount of sugar they contain. They contain more or less of a sirupy juice, which is in some varieties so abundant that it must be allowed to drain off before they can be packed.

The second type comprises sorts very like those just mentioned, but having a much lower percentage of sugar—not enough to keep them from fermenting and turning sour. They do not dry readily and are usually eaten fresh from the tree as a table fruit, being more like grapes than like ordinary dates. The very early sorts are of this category and do not stand shipment to long distances, though they will prove of great value for home consumption and may be sold on the

local markets. The Wolfskill date (see fig. 3) from Winters, Cal., is one of these sorts, as is also the Amaree, the earliest date known in the western Sahara, which has been recently introduced into Arizona.

The third category embraces what are known to the Arabs as "dry dates." These are almost entirely unknown to Americans or Europeans, but are very much esteemed by the Arabs, who consider them to be better for every day consumption than the soft dates, which latter they regard rather as a luxury than a staple food. These dry dates are not at all inclined to be soft or sticky when ripe, and are frequently so hard as to be difficult to eat. They are said to drop to the ground as they ripen, and are gathered by simply picking them up from beneath the palms as they fall. If stored in a dry place and protected from weevils, they may be kept for years without deteriorating. Dates of this type are as yet wholly unknown in our markets, but inasmuch as they are often of excellent flavor,[a] and are cleaner, keep better, and are more easily gathered and packed, they can be sold cheaper than soft dates. It is not unlikely that the best sorts of dry dates may become favorably known and may be eaten in place of Deglet Noor dates as a dessert fruit, especially when the latter sort is out of season; say, from April to October.

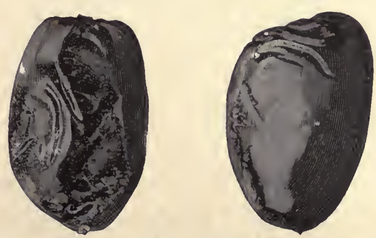

FIG. 3.—Wolfskill dates grown at Winters, Cal.

Mr. O. F. Cook suggests that dry dates may attain popularity as a result of the modern tendency toward the use of nuts, cereal preparations, and other foods which do not require cooking, since they would be preferable to the sweeter soft dates as a regular article of diet, and could be had at any time of the year in prime condition.

VARIETIES OF DATES SUITABLE FOR CULTURE IN THE UNITED STATES.

When the writer made his last journey to the Sahara in order to secure offshoots for planting in the Cooperative Date Garden at Tempe, in Arizona, and even when his first report[b] on the date palm was pub-

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[a] A palm which bears dry dates of excellent quality, though of rather small size, was imported by the Department of Agriculture in 1889, and has fruited for some years in the Salton Basin in southeastern California at Coachilla. This palm is probably a seedling and not an offshoot of a named variety as was at first supposed; it may be called the Coachilla date, and has fruits about $1\frac{1}{4}$ to $1\frac{1}{2}$ inches long and five-eighths inch wide. They are brownish amber in color, much wrinkled, and have a dull meal bloom on the surface. The seed is small, light gray in color, blunt, and with a more or less evident furrow on the back. The flesh, though hard, is free from fiber and of very good flavor, with a persisting and agreeable aftertaste.

[b] "The date palm and its culture," Yearbook of the Department of Agriculture, 1900; also reprinted and distributed separately.

lished, it was doubtful whether the best late-ripening sorts of dates could succeed in any of the arid regions of the Southwest which had then been irrigated, and consequently particular attention was given to early-maturing sorts, sure to ripen fully in most parts of Arizona and California. Many early sorts have been secured by the writer from the Sahara, among them the Amaree, Tedmama, Areshtee, Hal-looa, Teddala, Timjooert, Rhars, Tennessin, and Bent Keballa, and Mr. D. G. Fairchild has recently secured the Hayani, the earliest sort grown in lower Egypt. Several medium or early sorts already exist in California and Arizona—among others the Seewah, imported from Egypt by the Department of Agriculture some thirteen years ago, and a number of seedlings which have originated in this country, such as the very early Wolfskill (see fig. 3), the moderately early Lount No. 6, and the Bennet date (see fig. 4), which latter has a remarkably low proportion (1 to 11) of pit to flesh. With so many early and medium sorts to choose from, it is probable that some can be found capable of ripening all along the northern range of date culture in Texas, New Mexico, and Arizona, and throughout the interior valley region of California.


FIG. 4.—Bennet date, from Phoenix, Ariz.

The Rhars, in particular, is a promising variety for cooler climates, as the fruit ripens very early and is of good quality, while the plant is very vigorous and easily propagated by offshoots. Its principal drawback is that the fruits are sticky, being so full of sirupy juice that they are difficult to cure, and must usually be packed closely in skins or boxes for shipment. It is not improbable, however, that a good system of curing and packing would get rid of this sirup and leave the dates in a condition like that of the oriental dates commonly sold in America.

A large number of the offshoots of the Rhars variety was obtained in 1900, part being sent to California and part to Arizona.

The Rhars offshoots planted at Tempe in July, 1900, have made a remarkable showing; nearly 10 per cent of the plants (17 out of 176) flowered and bore a small crop of fruit only two years after being set out. "The Rhars proved to be an exceedingly sweet, tender-skinned date, maturing in September and October, and can probably be grown in cooler localities than Salt River Valley."[a] Professor Forbes writes that, "judging from preliminary experience, the Rhars seems to be a good commercial date, being very sweet, and drying in ten days to two weeks time to a firmness permitting of packing and shipping.

[a] Forbes, R. H. Thirteenth Annual Report, Arizona Experiment Station, 1902, p. 243.

They seem to be dry enough to pack when they are down to about 85 to 80 per cent of their fresh weight."[a]

The Teddala is another early sort, having a great advantage over the Rhars in that its fruits can be cured without difficulty. This variety was brought into notice by M. Yahia ben Kassem. It is a very large date, often 3 inches long, and ripens about the same time as the Rhars. It is as yet but little known, even in North Africa, but is a very promising sort. The palm is exceedingly vigorous and bears large crops of fruit. This variety is now growing at Tempe.

It has been noted on page 61 in treating of the heat requirements of the date that hardy rather than early sorts are needed for southern Nevada and southwestern Texas, where the summers are long enough and hot enough to ripen even late sorts, but where the winters are sometimes very cold.

Now that considerable areas in the Salton Basin have been put under irrigation, there is at last open to our enterprising fruit growers a region superior to most parts of the Sahara for date culture, in which even the latest and best sorts will ripen perfectly. It now becomes of great importance to secure these late varieties for trial, as they comprise the choicest sorts which bring the highest prices on the American and European markets.

THE DEGLET NOOR DATE.

Among these late sorts one in particular is worthy of special mention, the famous Deglet Noor.[b]

This sort is of medium or large size, oval in outline, dark amber colored, and translucent, with a small, pointed pit. The flesh is firm, very sweet, and of exquisite flavor and aroma. This date, if properly handled, remains clean, with the skin smooth, unbroken, and dry, so that when served as a dessert fruit it has a most appetizing appearance, very unlike the ordinary sticky, misshapen dates from the Persian Gulf region. A bunch of dates showing how the dates are attached is represented on Plate XXII (see also Yearbook, 1900, Pl. LX), while several dates and a few pits, all natural size, are shown on Plate IX.

The palm which produces these dates has a slender trunk, bearing long, narrow leaves, which stand more upright than those of most other sorts. The bunches of fruit have long, slender stems, which allow them to hang down when the dates are ripe (Pl. XXII). The slender, upright leaves give this variety a characteristic appearance, which enables it to be recognized easily even when growing with other sorts.

[a] Forbes, R. H., in letter to the writer, dated Tucson, January 9, 1903.

[b] In French orthography Deglet Nour; also called Deglet en nour, or Deglat ennour.

The fruits undergo no special preparation for the market, but are simply sorted and packed carefully in boxes suitable for the retail trade. Such boxes are shown in figure 5 and on Plate X. They contain from two-thirds of a pound to 11 pounds, and are especially in demand in Europe for the Christmas markets. The smaller boxes usually reach the larger markets of this country in January and sell at from 30 to 40 cents each retail, or at the rate of 45 to 60 cents a pound for the dates. The writer was assured by some of the largest producers in Algeria that the supply did not equal the European demand and that large American orders were refused, while, on the other hand, at one of the

FIG. 5.—Deglet Noor dates from the Algerian Sahara, showing methods of packing for retail trade.

largest wholesale and retail groceries at San Francisco it was said that any quantity could be sold at 35 cents a box (50 cents a pound), if they could be secured before the holidays. At the same time, selected Smyrna figs were selling in 1-pound boxes for 30 cents. It is clear that this date has little in common with the sorts which reach our markets in bulk from Bassorah, at the head of the Persian Gulf, and from Maskat, Arabia. If these Deglet Noor dates could be sold for half what they now bring (which would still be about five to ten times the wholesale selling price of this sort in the Sahara), the consumption could be enormously increased in this country, as they would not

compete with the common dates, but would be used as a choice dessert fruit and for confectionery.

The Deglet Noor is a very late variety, which requires an enormous amount of heat in order to mature properly. It does not succeed very well at Biskra, and only in the interior of the Sahara, where the summer temperatures are higher, is it of the best quality. The finest Deglet Noor dates are produced in the sunken gardens "ghitan" (fig. 8, p. 69) of the Souf country in the Algerian Sahara (see map, Pl. II, p. 76), where the heat is doubled by reflection of the sun's rays upon the leaves from the sides and from below, by the sloping sandy sides of the excavations, in the bottom of which the date palms are planted. As is shown in considering the heat requirements of the date palm (pp. 67–69), this sort may not be able to ripen fully in the Salt River Valley, Arizona, but it will surely attain the most complete maturity in the Salton Basin and will probably ripen earlier there than in the Sahara, which will allow the dates to be placed on the markets in ample time for Christmas, while in the warmest situations hand-picked dates probably can be shipped for Thanksgiving. The certainty that this choice variety can now be grown in the United States adds a new interest to date culture, and doubtless many progressive fruit growers will soon be planting Deglet Noor date palms, the culture of which gives every promise of being exceedingly profitable (see p. 136). A full-grown Deglet Noor date palm has been variously estimated to yield from 40 to 60 kilos (88 to 132 pounds) a year on the average, and certain trees in the sunken gardens of the Souf country in the Sahara yield as much as 330 pounds of fruit. In the Oued Rirh country the yield is irregular and a good crop is said to be followed by a poor one and then by a moderate one, making one good and one medium crop every three years. It has been found by the French companies that of the dates yielded by the Deglet Noor palm about one-fourth are of the first grade, suitable for packing in small wooden boxes (see fig. 5, p. 34, and Pl. X), holding from 4½ to 11 pounds, about one-third are second grade and are packed in the two-third pound oval paper boxes, such as reach our markets, and the remainder, a trifle over one-third, are third-class dates to be sold in bulk.

Unfortunately the Deglet Noor variety does not produce very many offshoots and does not grow so rapidly as do most of the less valuable sorts. In 1900 the writer secured 87 offshoots of the Deglet Noor, which were planted at the Cooperative Date Garden at Tempe, Ariz. (See Pls. XXI and XXII). Of these 47 are now alive and growing and in a year or two it will be possible to state with certitude whether this valuable variety will mature in the Salt River Valley.[a]

[a] One Deglet Noor palm at Tempe bloomed in 1902, but did not mature its fruit successfully. (R. H. Forbes, Thirteenth Annual Report, Arizona Experiment Station, 1902, page 243.) Several bloomed in 1903, but still no fruit matured.

It would be desirable to test this sort in the Salton Basin, and if possible some offshoots will be secured by the Department of Agriculture directly from the Sahara, since it will be some two or three years before any can be taken from the plants now growing at Tempe.[a]

The Deglet Noor is by no means common in the Sahara, and according to Masselot[b] it was carried about two hundred and forty years ago from the oasis of Temassin near Tougourt, where it originated, to the oases of southern Tunis. It had then been known in Temassin only about sixty years, so the variety is about three centuries old. Masselot gives the following account of its origin as told by the Arabs: "A revered saint, Lella Noora, had the habit of making daily ablutions at a point in the oasis of Temassin called 'Blidet-Amar.'[c] A seed sprouted fortuitously at this point and produced a palm of a new sort of degal (soft date) which was called degal ennoura or deglat ennour in remembrance of the saint." Most authorities derive the name from the Arabic *noor* "light" and "*degal*" or "*deglet*," "soft date," meaning "the date of the light" or "the transparent date." This is considered by Masselot as an error, as some other sorts are more transparent; he maintains that the name means simply "Noora's date."

THE KHALAS DATE.

Mr. Fairchild has also very recently (summer of 1902) secured at Bahrein offshoots of the famous Khalas, a date from the province of Lahsa or Hassa in eastern Arabia, near the Persian Gulf. Cuinet,[d] in his celebrated work on Turkey, refers to it as the most delicious of known dates.

The celebrated traveler Palgrave mentions this variety as occurring in the province of Hassa between Hofhoof and Mebarraz in east-central Arabia, and says:[e]

Here and for many leagues around grow the dates entitled "Khalās"—a word of which the literal and not inappropriate English translation is "quintessence"—a species peculiar to Hassa, and the *facile princeps* of its kind. The fruit itself is rather smaller than the Kassem date, of a rich amber color, verging on ruddiness, and semi-transparent. It would be absurd to attempt by description to give any idea of a taste, but I beg my Indian readers at least to believe that a "Massigaum" mango is not more superior to a "Jungalee" than is the Khalās fruit to that current in the Syrian or Egyptian marts. In a word, it is the perfection of the date. The tree that bears it may by a moderately practiced eye be recognized by its stem, more slender than that of the ordinary palm, its less tufted foliage, and its smoother bark. * * * Its

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[a] An experimental date orchard has been established very recently in the Salton Basin at Mecca (Walters), Cal. Several large Deglet Noor palms have been transplanted from Tempe to Mecca and many Deglet Noor offshoots have been ordered from the Sahara. (See footnote, p. 110.)

[b] Masselot, F. Les dattiers des oasis du Djerid. in Bulletin de la Direction de l'Agriculture et du Commerce, Tunis, vol. 6, No. 19, April, 1901, pages 117–118.

[c] Bled et Ahmar near Temacin (Map, Pl. II, p. 76).

[d] Cuinet, La Turquie, Vol. III, p. 233.

[e] Palgrave, William Gifford. Narrative of a Year's Journey Through Central and Eastern Arabia, Vol. I, London, 1865, pp. 172–173.

cultivation is an important item among the rural occupations of Hassa, its harvest an abundant source of wealth, and its exportation, which reaches from Mosoul on the northwest to Bombay on the southeast, nay, I believe to the African coast of Zanzibar, forms a large branch of the local commerce.[a]

Mr. Fairchild says Europeans and Arabs in that region agree in considering it to be the best date in the world. He further says:

I do not hesitate to pronounce it second or third only to the *Deglet Noor*, which it even surpasses in *date* flavor. I have always thought the Deglet Noor a most delicate date, but lacking in that indescribable *date* flavor which characterizes these Persian and Arabian sorts. The Khalas is a sticky date, but of most unusual flavor.[b]

In his report on the "Persian Gulf Dates" Mr. Fairchild says:

The skin is a golden brown and of most delicate texture, covering closely the rich golden flesh, which is of exquisite date flavor and with the consistency of a chocolate caramel.[c]

OTHER PROMISING DATES.

Among numerous other sorts secured by the writer from various regions in the Algerian Sahara and now growing in the Cooperative Date Garden at Tempe, Ariz., the following are especially noted for their superior quality, all being considered by some to equal or to be superior to the Deglet Noor in flavor.

(1) The Teddala, a very large, very early sort from M'Zab in western Algeria (see page 33).

(2) The Iteema, a midseason date, short and round, with soft flesh, very sweet, said to keep well; in Tunis it is very much esteemed and is considered suitable for export.

(3) The Bent Keballa, possibly a large form of the Iteema, considered one of the best varieties in M'Zab.

(4) The Timjooert, also from M'Zab, a medium-sized red date, so full of juice that the fruit drips honey from the tree when ripe; when properly cured keeps well and is of most excellent quality; flesh granular with almost no fibers about the seed; very sweet.

(5) The Hamraya, a very large, dark-red date, ripening very late; flesh free from fiber and of good flavor; in Tunis it is the largest date known and one of the two heaviest bearers,[d] the average yield being 220 pounds per tree.

(6) The Mozaty or Mazauty date, from the Pangh Ghur country[e] in Baluchistan, recently secured by Messrs. Lathrop and Fairchild, has been highly extolled. It is said by Fischer, in his monograph of the

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[a] Mr. D. G. Fairchild reports that Khalas is a delicate packer and is nowadays never exported except in form of presents. (See Bul. 54, Bureau of Plant Industry, U. S. Department of Agriculture, 1903, p. 25.)

[b] Fairchild, D. G. In letter dated Bassorah, February 22, 1902.

[c] Fairchild, D. G. Persian Gulf Dates and Their Introduction into America. Bul. 54, Bureau of Plant Industry, U. S. Department of Agriculture, p. 25.

[d] The Areshtee is the other. (See page 26, footnote *a*.)

[e] Some thirteen days' caravan journey from the port of Gwadur, on the Gulf of Oman.

date palm, to be "the best date in the celebrated date region Pandschgar."[a] This variety is reported by Mr. Fairchild to be one of the finest in the world; it "is packed in date syrup in small jars and sold as a great delicacy in the Kurrachee market." Such preserved Mozaty dates were eaten by Mr. Fairchild in February, 1902, at Kurrachee. He says, "They impressed me as the richest flavored dates I had ever tasted."[b]

THE ORDINARY DATES OF COMMERCE.

The standard varieties of dates which are grown along the Shat-el-Arab River and which are exported from Bassorah to America and Europe in enormous quantities have recently been secured and introduced into this country by Messrs. Lathrop and Fairchild. The principal varieties grown for export in this region are the Halawi, Khadrawi, and the Sayer. Of these the Halawi is doubtless the best; it is a medium-sized, rather light-colored, sticky date, and forms the best grade of the ordinary dates imported into America. The tree grows well on an adobe soil and needs much water. From the region about Maskat Messrs. Lathrop and Fairchild secured the Fard date, of which about 1,000 tons a year are exported. It is largely shipped to America, but it is darker colored and inferior in flavor to the Halawi of Bassorah, according to Mr. Fairchild,[c] whose recent bulletin should be consulted for a detailed account of the varieties and methods of culture observed by him in a trip through the oriental date regions.

VARIETIES OF DATES THAT SHOULD BE SECURED FOR TRIAL IN THE UNITED STATES.

There are other very promising late sorts which should be secured as soon as possible, even at considerable expense, in order that they may be tested in the Salton Basin and in Arizona in comparison with the Deglet Noor.

Among these may be mentioned the Menakher (or Monakhir) of the Tunisian Sahara, a variety later than the Deglet Noor, with large brown fruits which attain the length of the little finger. This sort is rare and much sought after in the Tunisian Sahara, where it sells for slightly more than the Deglet Noor, which it surpasses in length by 50 per cent and to which it is by many considered superior in quality. The average yield of a Menakher palm is said to be 30 kilos or 66 pounds, only half the yield of the Deglet Noor. The offshoots are more costly than those of the Deglet Noor, selling at from 4 to 6 francs each, while those of the Deglet Noor cost only 2 to 3 francs, and the ordinary sorts from 1 to 3 francs.

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[a] Fischer, Th. Dattelpalme, p. 26.

[b] Fairchild, D. G. Persian Gulf Dates and Their Introduction into America. Bul. 54, Bureau of Plant Industry, U. S. Department of Agriculture, 1903, p. 27.

[c] Fairchild, D. G. Persian Gulf Dates and Their Introduction into America. Bul. 54, Bureau of Plant Industry, U. S. Department of Agriculture, 1903, p. 25.

Another sort of great promise is the Wahi, of which samples were secured by Mr. Fairchild in the market of Fayoum, in west-central Egypt. This variety is said to come from the oasis of Seewah, known to the ancients as Ammon, or Ammonium, some 300 miles to the westward, in the interior of the Sahara Desert. The date is brown, less transparent than the Deglet Noor, but rather longer and decidedly broader; the seed is blunter and much more irregular in outline. The flesh is yellowish, granular midway between the skin and the seed, and of a most delicious flavor. This date had been gathered and kept, with no precautions against drying out, for at least eight months when it was received at Washington, but it was still in very good condition, except for the attacks of weevils. It seems to be a better keeper and to have a higher flavor than the Deglet Noor. Nothing is known as to the palm which produces this date, but from the quality of the fruit it is presumably a late-maturing variety.

Dates of a superlatively good quality are reported from Morocco, and Mr. O. F. Cook[a] obtained some years ago at Tangiers, from a European official in the employ of the Sultan, dates which he considers superior to the Deglet Noor. These dates were about as long as and somewhat thicker than the Deglet Noor, but more wrinkled and of a darker color. They were covered with a bloom and were so dry that the flesh was firm and not at all sticky. At London a prominent produce dealer in Covent Garden market assured the writer that the Tafilet dates were better than the Deglet Noors, which are also much appreciated in England. Inasmuch as the drier grades of Deglet Noor dates are preferred in England, it may be that the Tafilet dates of the London markets are the same as the dry variety Mr. Cook secured at Tangiers. No good dates are produced west of the Atlas Mountains in Morocco, and any sort of superior quality must come from the Moroccan Sahara, very probably from Tafilet, the largest and most important Moroccan oasis, though Mdaghra and Tissini are also reported to produce excellent dates. Rohlfs,[b] the celebrated African explorer, says: "The dates of Tafilet are known as the best in the whole desert; the varieties Buskri, Bu Hafs, and Fukus are most sought and bring the highest price."

The importance of securing a date possibly superior to the Deglet Noor would warrant sending Arab or Berber merchants to these oases to investigate the quality of the dates and to secure offshoots of the better sorts. In the present unsettled state of trans-Atlasian Morocco it would be hazardous for Americans or Europeans to venture there.

The Mirhage date of Mandalay, some three days' journey from Bagdad, and the very similar but somewhat inferior Maktum of Bagdad,

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[a] Oral communication to the writer, 1900.

[b] Rohlfs, Gerhard. Tagebuch seiner Reise durch Morocco nach Tuat. In Petermann's Geographische Mittheilungen, 1865, Heft 5, p. 175.

are considered by Mr. Fairchild as being very promising sorts. The Maktum is "a soft, sticky date with a small stone, no fiber, and a beautiful golden-brown skin which adheres closely to the golden, brownish-yellow flesh."[a] It matures in August. Unfortunately the Mirhage could not be secured by Mr. Fairchild at the time of his visit to Bagdad in 1902, though he sent the Maktum to this country, where it is now growing.

The dates of Bafk and Terachabad, in Persia; of Medina[b] and Tur,[c] in western Arabia; of Kasem, in central Arabia; of Nedjed, in eastern Arabia; of Say and Sukkot,[d] in Nubia; of Dakhel, in western Egypt; of Traghen, in Fezzan; and of Tafilet, Mdaghra, and Tissini, in eastern Morocco, have been lauded by experienced travelers, and if possible these oases should be visited and offshoots secured of the best sorts, since it is now possible to bring even the latest varieties to full maturity by planting in the Salton Basin. Heretofore the uncertainty as to the possibility of growing the best late sorts has discouraged any attempt to obtain the varieties from the more remote regions; but now, when date culture is still in its infancy, is just the time when these sorts should be secured and tested, in order that no mistakes be made and so that only the best sorts be planted out. Once planted, a date palm can not be changed to another variety, as can all other ordinary fruit trees, for palms can not be grafted or budded. To change the variety it is necessary to dig up the old trees and plant young offshoots of the sort desired; in other words, to destroy the old orchard and plant a new one.

In view of the fact that offshoots are now very expensive, and that it costs more to plant an acre to date palms than to any other fruit tree, and in view of the fact that date palms can be propagated only at a slow rate by removing one or two offshoots annually and can not be increased indefinitely by budding or grafting, as with other trees, it becomes very important to secure a collection of the best sorts of date palms as soon as possible, in order that all the best varieties may be

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[a] Fairchild, D. G. Persian Gulf Dates and Their Introduction into America. Bul. 54, Bureau of Plant Industry, U. S. Department of Agriculture, 1903, p. 23.

[b] "The best kind [of Medina dates] is Al Shelebi; it is packed in skins or in flat, round boxes, covered with paper, somewhat in the manner of French prunes, and sent as presents to the remotest parts of the Moslem world. The fruit is about 2 inches long, with a small stone, and is seldom eaten by the citizens, on account of the price, which varies from 2 to 10 piasters [about 9 to 43 cents] the pound. The tree, moreover, is rare, and is said not to be so productive as the other species." (Burton, Narrative of a Pilgrimage to Mecca, vol. 1, pp. 400–401.)

[c] "The small, yellow dates of Tur * * * are delicious, melting like honey in the mouth, and leaving a surpassing *arrière goût.*" (Burton, Narrative of a Pilgrimage to Mecca, vol. 1. p. 204.)

[d] "In Nubia the dates of Ibrim are celebrated, but still more so those of Sukkot and Say, the sweet aromatic Sultani, which attain a length of 3 inches." (Fischer, Die Dattelpalme, p. 25.)

compared and that there may be time to secure a supply of offshoots before the "rush" begins and whole regions are planted to dates.

Fortunately it will doubtless be possible to secure the Rhars for the cooler arid regions and the Deglet Noor for the hottest deserts in any desired numbers when once the demand for the offshoots exists.

INTRODUCTION OF SAHARAN VARIETIES OF DATE PALMS INTO THE UNITED STATES.

Seedling dates have long been growing in California and Arizona, and still longer in Mexico, but only recently have successful importations been made of offshoots of date palms, by which alone the varieties can be propagated. In 1889 the Division of Pomology of the Department of Agriculture imported some 59 offshoots from Egypt, 9 from Algeria, and 6 from Maskat, and, although many were lost, those sent to the Arizona Experiment Garden in Phoenix, in the Salt River Valley, grew well and fruited at an early age. (See Yearbook, 1900, Pl. LXII, fig. 1.) It was, however, found that most of the offshoots from Egypt had been falsely named; many bearing the names of valued sorts proved to be ordinary males of no value. Some few female palms bearing fruit of fair quality were included in the shipment, however, and the success of these proved the Arizona climate and soil to be suited to the culture of at least the Egyptian sorts. Prof. James W. Toumey first directed attention to the success of the date palm in central Arizona, as evidenced by the production of an abundance of fully matured dates, both by the seedlings planted by American settlers and by offshoots imported by the Department of Agriculture.[a] It was the success of these early importations which rendered it desirable and feasible to undertake the recent large importations of offshoots made in 1899–1900.

Shortly after the organization of the Section of Seed and Plant Introduction in the Department of Agriculture in July, 1898, attention was directed to the desirability of securing a large assortment of correctly named offshoots, particularly from the Algerian Sahara, whence are exported the best dates which reach Europe and America. The University of Arizona and the Arizona Agricultural Experiment Station meanwhile offered to provide a special date garden, and to set out, irrigate, and cultivate the palms, if the Department of Agriculture would furnish a collection of offshoots of the best sorts of dates grown in the Old World. This offer was accepted, and in the winter and early spring of 1899 the writer visited, under instructions from the Secretary of Agriculture, the oases in the Sahara Desert about Biskra, Algeria. A few offshoots were secured and forwarded as a trial

[a] Toumey, J. W. The Date Palm. Bul. No. 29, Arizona Experiment Station, Tucson, Ariz., June, 1898, pp. 50, figs. 13.

shipment, and a large number was contracted for, to be delivered the following spring.

In May and June, 1900, the writer again went to Algeria for the purpose of shipping to Arizona the date offshoots previously contracted for and to purchase such additional offshoots of good sorts as could be had. As a result of this second visit 440 offshoots, consisting of some 27 varieties, were obtained and shipped (see Pl. VI) to the Cooperative Date Garden at Tempe, Ariz., where 384 of the offshoots were planted (see fig. 6 and Pls. XXI and XXII). Of the remainder 21 were sent to Phoenix, Ariz., and 35 to the date gardens at the substations of the California Experiment Station at Pomona and Tulare and to private growers in California.

FIG. 6.—Cooperative Date Garden at Tempe, Ariz. The offshoots imported from the Algerian Sahara in 1900 have just been set out and a workman is planting one in the foreground. From negative by Prof. R. H. Forbes, August, 1900.

This shipment, which was the largest that ever left North Africa, came through in two months and arrived in good order. An innovation was made in packing the offshoots. It had been the custom to send them rooted in tubs, entailing the great expense of a year or two of care in a nursery to get the plants properly rooted, and then heavy freight charges on account of the bulk and perishable nature of the plants. The writer shipped the offshoots packed simply in boxes with damp moss about the bases,[a] in charcoal, or in straw, with no moisture whatever (see p. 21). A late report of Prof. R. H. Forbes, director of the Arizona Experiment Station, who gave his close

[a] For fuller details see the writer's report, "The date palm and its culture," in Yearbook, Department of Agriculture, 1900.

personal attention to the planting and subsequent care of these offshoots, shows that of the entire 384 plants set out in the Cooperative Date Garden at Tempe and at Phoenix, 294 were living, while 90 were dead.[a] These figures show that over 75 per cent of the offshoots have become established. (See Pls. XXI and XXII.) More than 80 per cent of those sent directly from the Sahara by the new system of packing lived, but the average was reduced by the plants that had been grown in tubs a year before shipment, of which only about 58 per cent lived. The offshoots simply packed in straw came through as well as those carefully wrapped about the base with moist moss or packed in charcoal. Inasmuch as only 70 to 75 per cent of the offshoots are expected to live in the Sahara when they are planted in the open without protection, as was done at Tempe,[b] the remarkable record was made of securing the growth of more offshoots in Arizona after a two months' voyage than would be expected to live in the Sahara, and that, too, even with the most inexpensive method of shipment that could be imagined—that of simply packing the suckers closely together in dry straw in ordinary wooden cases.

This experiment has demonstrated the possibility of importing date offshoots from the Sahara and placing them in the deserts of the Southwest in practically as good condition as when they were cut off the parent tree. The importance of this experiment is obvious, for it renders it certain that offshoots can be transported to great distances without loss, and makes it possible to undertake the culture of dates on a commercial scale by importing offshoots for planting. Doubtless means will be found to supply the demand for offshoots as soon as it arises by importation from the Sahara. In the meantime many of the best sorts of southern Algeria are on trial at Tempe, Ariz., and doubtless some will be found adapted to the climatic conditions there.

As was previously noted in the paragraph on varieties, it is greatly to be desired that the Deglet Noor and other late sorts be set out as soon as possible in the Salton Basin, in order that there may be a practical demonstration of the suitability of this region for the culture of the choicest sorts of dates.

THE DATE PALM AS A SHELTER FOR OTHER FRUIT TREES.

In many parts of the northern Sahara the date palm is almost as important as a shelter and partial shade for other fruit trees as it is for its own fruit. At the time of the Roman occupation of Africa these oases were largely planted to olive trees, some of which, indeed, still remain—giant stems perhaps 1,500 years old. It happens that the

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[a] Forbes, R. H. Thirteenth Annual Report, Arizona Experiment Station, 1902, p. 242.

[b] Marcassin. L'agriculture dans le Sahara de Constantine. In Annales de l'Inst. Agronomique, 1895, p. 62 of reprint.

olive is about the only other fruit tree which is able to stand without injury the fierce heat, intense light, and the driving sand storms of the Sahara, and even the olive itself grows better and yields more fruit if planted under the protecting shelter of the date palm. Most other fruit trees, such as the apricot, peach, almond, pomegranate, fig, and jujube, can be grown successfully in the Sahara only in the shade of other trees, and do best where grown under the date palm. In the northernmost oases of the Sahara the dates are frequently of inferior quality, whereas the other fruit trees do better here than in the hotter and drier regions farther south. Many of these northern oases have veritable orchards growing under the half shade furnished by the crown of slender leaves of the date palms far above. This is well shown in Plate XII, which represents a fig orchard growing under date palms at Chetma, Algeria. It sometimes happens that vegetables are grown under the fruit trees, in which case it is possible to see three crops occupying the soil—first, the date palm, towering far above; then the fruit trees, and under them the more delicate and shade-loving garden vegetables. It is not at all impossible that in some parts of our own Southwest the date palm may prove very useful in the manner above described, serving as a shelter and partial shade to more delicate fruit trees which thrive perfectly in regions where the summers are far too cool to allow of the culture of the best sorts of dates.

IRRIGATION OF THE DATE PALM.

AMOUNT OF WATER NECESSARY FOR A DATE PALM.

The date palm requires a continuous supply of moisture about the roots and can not maintain itself in as dry a soil as can some desert plants. Much experience has been accumulated by the French planters in the Algerian Sahara as to the amount of water necessary to enable a date palm to grow and fruit well. M. Jus, the celebrated civil engineer, who has done so much to reclaim the northern Sahara by a study of its artesian water supply, considers[a] that each palm tree requires one-third of a liter (0.35 quart) per minute at the flowing well or main irrigating canal, and palms which receive from 0.4 to 0.5 of a liter (0.42 to 0.53 quart) per minute are more vigorous and yield more fruit even if crops are grown underneath. If each tree receives 0.35 quart per minute this would amount to 126 gallons per day, or about 17 cubic feet. At 1 pint per minute the daily consumption would be 180 gallons, or a little more than 24 cubic feet. These data are not for the amount of water actually furnished the trees, but for the amount which must be allowed for each tree at the head of the principal irrigating canals. Of course some of the water is lost by evaporation and seepage before it reaches the palms.

[a] Jus, H. Les oasis de l'Oued Rir', Paris (Challamel), 1884.

M. Rolland, who has written a very complete account of the water supply of the Algerian Sahara,[a] and who is himself one of the members of a firm which has created extensive date plantations in the Oued Rirh country, in the Algerian Sahara, considers that one-half liter (0.53 quart) per minute should be allowed to each palm to secure the best results.

M. le commandant Rose, himself an experienced planter, has published a most detailed statement[b] regarding the practice of irrigation in the Oued Rirh country, where the water supply is furnished by artesian wells. He recommends 24 irrigations of 3 cubic meters (792.5 gallons) each, making 72 cubic meters, or 19,021 gallons during the year. During the hot season, from June to September, inclusive, weekly irrigations are practiced, 17 in all, consuming 51 cubic meters, or 13,473 gallons per tree, which is at the rate of about 113 gallons per day, or about 0.314 quart (0.3 liter) per minute, the lowest of the three estimates. During the autumn and winter 2 irrigations, and during spring 5 irrigations, are prescribed.

When the supply of water is invariable, as for example the flow from an artesian well, it is necessary to plant only the number of palms that can be properly irrigated by the available water supply during the hot season, when the amount needed is greatest. Where irrigation is practiced by means of water conducted from rivers or from storage reservoirs in canals, as is the case in most of the arid regions of the Southwest, it will be even more necessary to determine carefully how much water can be had in summer to avoid planting more dates than can be properly irrigated.

In the plantations made recently by French proprietors in the Algerian Sahara, the date palms are usually set out 8 meters, or 26 feet, apart, making 143 to the hectare, or 60 to the acre. Some of the planters consider this distance too small and plant about 10 meters (33 feet) apart, making about 40 to the acre, while others, among them the celebrated civil engineer Rolland, consider 200 to the hectare, or about 80 to the acre, as being the best number to plant.

Taking 60 to the acre, 26⅔ feet apart, as a good number to plant, the amount of water needed per acre can easily be calculated. Using Rose's estimate of 19,021 gallons per tree per annum, 3½ acre-feet of water would be required, of which 2¾ acre-feet would be used during the four summer months from June to September, inclusive. Using Jus's estimate, which puts the least amount necessary at one-third

[a] Rolland, Georges. Hydrologie du Sahara algérien (chemin de fer transsaharien), Paris, Imprimerie nationale, 1894, p. 9.

[b] "La culture du dattier dans le sud constantinois, par un homme du sud." Alger, 1898, Pierre Fontana & Cie, Paris, Augustin Challamel. 8°. 20 pp. The identity of the author of this pamphlet was disclosed by Rolland (Hydrologie du Sahara algérien, p. 167).

liter (0.35 quart) per minute, or 126 gallons per day, a trifle over 4 acre-feet would be required, of which nearly 3 acre-feet would be used in the four hottest months, from June to September, inclusive. On the basis of Rolland's estimate, which is also given by Jus as the optimum quantity, viz, one-half liter (0.53 quart) per minute, or 190 gallons per day, some 5½ acre-feet a year would be required, of which 4 acre-feet would be used during the four summer months, or at the rate of 16 acre-feet per annum.

The amount of water needed per acre depends of course directly on the number of date palms per acre, and in planting care should be taken not to set out more than can be irrigated with the water supply covering the land.

It must be remembered that the figures given above are for the western Sahara, a region noted for its extreme dryness, where the evaporation from a free surface of water often averages nearly one-half inch per day during the three summer months—June, July, and August. It is probable that a smaller amount of water would suffice in regions where the air is not so dry and consequently where the evaporation is less, as, for example, in the Salt River Valley and most other parts of southern Arizona,[a] while in hotter, drier regions, such as the Salton Basin, even more will be required. In the latter region it will be well to allow only about 12 palms to each acre-foot of water available, and this only if the water can be had whenever desired during the summer. This would permit planting some 50 date palms to the acre where 4 acre-feet of water are available whenever needed during the year.

It must be remembered in considering the needs of the date palm that the water supply must be practically continuous; that is to say, that the ground must in some way be kept damp throughout the entire year. It is probable, however, that the date palm does not require as much water as do ordinary fruit trees. It is, indeed, probable that owing to their having thick, leathery leaves, protected by a coating of wax, they evaporate a considerably less quantity than would an ordinary fruit tree having delicate leaves not adapted to withstand the hot, dry air of deserts. It is nevertheless necessary for the roots to have

[a] At Tucson, Ariz., the average of three years' records taken at the University gives the annual evaporation from a free surface of water at 77.7 inches, and the average rate during the three hottest months, June, July, and August, at one-third inch per day. At Tempe, in the Salt River Valley, Arizona, a calculation by the United States Geological Survey from imperfect data gives 91 inches as the probable annual evaporation. At Biskra the careful records of M. Colombo show a mean annual evaporation during the ten years from 1884 to 1893 of 2.8374 meters, or 111.7 inches, averaging 12.47 mm., or 0.4915 inch (very nearly one-half inch) per day during June, July, and August. In the Oued Rirh country, where most of the observations relative to the amount of water necessary for irrigating date palms have been made, the rainfall is less than at Biskra and the temperature higher, so the evaporation is doubtless greater.

access to moist earth throughout the entire year, since, as has been stated above, the date palm is not at all a desert plant, in the sense of being able to exist on very dry soil, and would die in many of the situations in the Southwest where cacti and yuccas thrive.

Where the supply of irrigation water is limited, as at Biskra, where there is only 0.12 liter per minute available for each palm and where the soil is very heavy and consequently difficult to saturate, irrigation is commonly practiced by filling up with water a cavity—"dahir"—excavated at the base of the tree (Pl. XVII, fig. 2, and Yearbook, 1900, Pl. LV, fig. 3). Where water is more abundant and especially where crops are grown under the palms it is customary to flood the whole surface of the ground, the land being divided into small beds from 10 to 30 feet in diameter, which are surrounded by a slightly raised rim (Pl. XVII, fig. 1). When irrigated the whole bed is flooded, the water being retained by the surrounding ridge. A larger amount of water is required when applied in this manner than would be necessary if poured into a trench at the side of the palm, but the alkali is washed into the subsoil by surface flooding, whereas it is brought to the surface by the trench system, which should never be followed in dangerously alkaline soils. In the Salton Basin in particular, where the subsoil is often heavily charged with alkali, the land should always be watered by flooding or else by deep furrows, even where the surface soil does not contain harmful quantities of alkali.[a]

Where there is water at a short distance from the surface within reach of the roots, as is the case in the area about the Cooperative Date Garden at Tempe, Ariz. (see Pls. XXI and XXII), at Farfar, Algeria, in the western Zab, between Fougala and Biskra, Algeria (Pl. XIV, fig. 1, and Yearbook, 1900, Pl. LIX, fig. 7), and in the Souf country in the Sahara (fig. 8, p. 69) the amount of water required for irrigation is less when once the palms have become established. They can even exist without any irrigation whatever from the surface, although in this event they do not grow as well and bear very much less fruit, probably because of imperfect aeration of the soil about the roots and because of the continual rise of alkali from the subsoil, as will be explained in the chapter on drainage.

Well aerated running water is desirable for date palms and waterlogging of the soil must be prevented. If these conditions are fulfilled this plant can live and thrive when irrigated with water so salty as to kill all ordinary plants, as will be shown later in treating of the alkali resistance of the date palm.

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[a] Snow, Hilgard, and Shaw (in Bul. 140, Cal. Exp. Sta., pp. 36–39) recommend for the Salton Basin first washing the alkali down by surface flooding and then preventing its subsequent rise by deep-furrow irrigation. However, the date palm is not sensitive to surface accumulation of alkali when once established, as will be shown farther on (see p. 117).

Irrigation by means of flooding is sometimes practiced in Egypt for the date palm, as has been done for all sorts of crops since remote antiquity. The water covers the land to a depth ranging from a few inches to several feet (see Pl. XI), and remains on the soil for about six weeks.[a] This method of irrigation is not likely to prove desirable anywhere in this country unless it be in the flood-plain of the Colorado River in California and Arizona (see p. 131). It may be desirable to use this method of flooding in order to wash the alkali out of the surface layer of the soil where the accumulation of alkali in the upper layers of the soil is so great as to prevent the best growth of the date palm. It is of interest in this connection to note that the Egyptian date palms are able to endure having their roots submerged for long periods without appreciable injury.

Mr. D. G. Fairchild has described a very interesting system of combined irrigation and drainage practiced in the date plantations along the Shat-el-Arab River at the head of the Persian Gulf, which are doubtless the most extensive in the world. The level valley land along the river is cut up into small rectangles, 10 to 15 by 20 to 30 feet on a side, by irrigation ditches, through which, twice a day, water flows when the river is backed up by the tide. As the tide recedes the water flows out of the ditches, preventing stagnation and causing a lowering of the water level in the soil. The soil is doubtless thoroughly aerated by this alternate rise and fall of the level of the ground water. By this interesting system of tidal irrigation, which, without any trouble beyond the first labor of digging the ditches provides for very perfect watering, drainage, and aeration of the soil, date palms thrive in this region where the soil is as pure an adobe as the clay of a brickyard.[b]

Such a system of combined irrigation and drainage can, of course, be applied only where a river is backed up by high tides. No such conditions occur, or at least not on any considerable scale, within the date regions of the United States, since the region along the Sacramento River in California where tidal irrigation can be practiced is so cooled in summer by the cold winds and fogs from the Pacific that none but the very earliest sorts of dates could mature. Along the Colorado River, near its mouth in Mexico, it is possible that tidal irrigation could be used in date culture, since the tides in the Gulf of California are very high and the climate and soil in this region are favorable to the culture of early and midseason dates.[c]

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[a] Kearney, Thos. H., and Means, Thos. H. Crops used in the reclamation of alkali lands in Egypt, Yearbook, Department of Agriculture, 1902, p. 504.

[b] Fairchild, D. G. Persian Gulf Dates and Their Introduction into America. Bul. No. 54, Bureau of Plant Industry, U. S. Department of Agriculture, 1903, p. 14.

[c] However, the head of tide water is only about fifteen miles above the mouth of the river (as may be seen on fig. 10, p. 102), and consequently there is not room for such immense date plantations as those described by Fairchild around Bassorah.

In many parts of California and possibly in some parts of Arizona there is enough rainfall to support the date palm without irrigation (see p. 124). The Wolfskill date palm at Winters, Cal., for example, is never irrigated, yet bears abundant crops of good dates every year.

In regions where the winters are very cold it is unwise to irrigate late in summer, except when necessary to keep the palms alive, since abundant watering forces a tender new growth, which is likely to be killed by the freezes of the succeeding winter. At Tulare, in the San Joaquin Valley, California, where there are from 6 to 34 severe frosts every winter and where the temperature sometimes falls as low as 17° F. or lower, the gardeners of the substation of the Agricultural Experiment Station consider it unwise to irrigate date palms after the month of June.

WARM IRRIGATION WATER ADVANTAGEOUS.

The growth of the date palm and the maturing of its fruit are hastened by supplying warm water to the roots. For example, in the oasis of Chetma, Algeria (see Pl. XII and Yearbook, 1900, Pl. LIX, fig. 8), largely supplied with water from warm springs having a temperature of 94.1° F. (34.5° C.), the Deglet Noor date ripens early in the season, especially on those trees growing near the springs and which, consequently, receive warm water even in winter and early spring, when the air is still cold. Biskra, near by and at nearly the same level, though less protected against cold winds, is also irrigated largely from springs, but the temperature of the water of these springs is only 70° to 81° F. (21.5° to 27.33° C.), and the water is cooled in winter and spring by admixture with the run-off from the Atlas Mountains to the north and by flowing a couple of miles in open canals before it reaches the nearest date palms. Here the Deglet Noor date does not mature so well as at Chetma and is not of the best quality. The artesian wells of the Oued Rirh country (see map, Pl. II, p. 76) furnish water of a temperature ranging from 76.3° to 79° F. (24.6° to 26.1° C.), and in the Souf country the ground water to which the palms send down their roots is much colder, having a temperature of only 57.2° to 68° F. (14° to 20° C.); but in these regions the summer heat is much greater than at Biskra and usually suffices to enable the Deglet Noor to mature perfectly.

In the Salt River Valley, Arizona, the irrigation water is conveyed in open canals mostly shaded by cottonwood trees. The temperature of the water naturally varies with the season. In June, when the temperature of the air ranged from 82° to 104° F., Professor McClatchie found the temperature to range from 73° to 94° F. in the canals and from 82° to 88° F. in the smaller irrigating ditches. It should be noted that in June the supply of irrigating water is less than for any other month of the year, and probably in February, March, and April,

when the canals are full of the water from melting snows on the surrounding mountains, the temperature would be much lower.

The Salton Basin is supplied with water diverted from the Colorado River near Yuma and conducted some 40 to 60 miles in open ditches before it is put on the land. The annual overflow of the Colorado River occurs in early summer, usually in June or July, and is caused by the melting of the snows on the Rocky Mountains in Colorado, Utah, and Wyoming. This cold water fortunately reaches the Colorado Desert at a time when the heat is great, so that in flowing in the large open canals and in the shallow laterals and in soaking through the hot surface layers of the soil it will undoubtedly be warmed considerably before it reaches the roots of the date palms. On the whole the conditions are exceptionally good in the Salton Basin, for the most abundant supply of water occurs in early summer or midsummer, just when the plants have greatest need for it.

The annual overflow of cold waters from the melting snows is doubtless the principal cause of the failure of the date palms to mature their fruit properly on Mr. Hall Hanlon's place in the Colorado River flood plain in California, near Yuma, Ariz. (see Pl. XX, fig. 2). The temperature of the soil and of the air in this overflowed area and in adjoining areas at nearly the same level is doubtless much lower than at the town of Yuma, for instance.[a] Even at Yuma the summer heat is less than at Phoenix and very much less than in the Salton Basin. It is clear then that no conclusion unfavorable to the culture of dates in the Salton Basin can be drawn from the failure of these palms in the flood plain to mature their fruit. Early varieties, such as the Rhars and Teddala, will probably ripen even on these overflowed lands (see p. 132).

DRAINAGE FOR THE DATE PALM.

Although the date palm can withstand very much more alkali than any other crop plant, it does not endure having the soil about the roots water-soaked. Good drainage is as essential for it as for any other fruit tree if good crops are to be expected, and, unless the soil drains naturally, the superfluous water must be removed, usually by means of open ditches or with tile drains. Proper aeration of the soil about the roots is essential to enable the date palm to grow well and yield abundantly (see p. 80). Good drainage also permits the alkali to be washed out of the soil by means of heavy irrigation, and, doubtless, this also favors the growth of the palms. It is, however, worthy of being noted that the excessively alkaline water which flows off in the drainage ditches is used in some parts of the Sahara to irrigate date palms which occupy land lying at a lower level. Such palms, though

[a] According to Mr. Bernard G. Johnson, of Mecca, Cal., there is a drainage of cold air from the hills toward Mr. Hanlon's date plantation which renders it one of the coldest sites in the vicinity of Yuma.

less vigorous than those receiving good water, nevertheless produce moderate crops of fruit (see p. 98).

In most date plantations made by the French in the Sahara, drainage is provided by means of open ditches from 2 to 6 feet deep, running between alternate rows of palms, or at distances of about 50 feet apart (see Pl. XVII, fig. 1). Very unusual conditions of drainage are found at the oasis Fougala, Algeria (see Pl. XV, fig. 1), as will be explained in treating of the alkali soils collected at that place (pp. 78 and 84). The superfluous water there runs off through holes in an impervious hardpan, and the downward flow of water through the holes, induced by surface irrigation, has washed the alkali out of the surface soil, has aerated the subsoil, and has had marvelous effects in promoting the growth and increasing the yield of the date palms, which had managed to live for years before surface irrigation was begun with the supply of water absorbed by the roots from below the hardpan layer.

It will doubtless be found necessary to irrigate date palms about Tempe, Ariz., even where their roots penetrate to the subsoil constantly wetted by the water that seeps down from the irrigated fields located at higher levels. Unless this is done the palms are likely to become stunted and sterile, as they were at Fougala before surface irrigation by artesian water was commenced.

The presence of a hardpan layer, as at Fougala, may be advantageous in providing a means of drainage through holes made under each tree, while at the same time confining the drainage water below the hardpan, thereby preventing its rising to the surface by capillarity and carrying with it the alkali of the subsoil. When no hardpan exists, as at Tempe, a certain amount of drainage can nevertheless be accomplished, since the water applied at the surface drains into the great body of ground water, which has a practically constant level unless raised by excessive irrigation. In case the subsoil is too impervious to permit quick seepage from the surface to the ground water, outlets for drainage water can sometimes be provided advantageously by putting down wells.

In most parts of the Salt River Valley the natural drainage is good and no ditches or tile will be needed. In the Salton Basin drainage is impeded by the impervious nature of the clay, which occurs in many places as surface soil and nearly everywhere as subsoil. Drainage is especially desirable here, for the subsoil is often laden with alkali even where the surface soil is free from harmful quantities of salts. Natural drainage, nevertheless, will probably suffice for the date palm in many parts of this region, provided the level of the ground water is not raised too high by excessive and ill-timed irrigation. In some places, where natural drainage is insufficient, occasional open ditches will provide adequate drainage, especially where the soil is a sandy

loam or a loam. The lands lying near the New River or Salton River beds, or near Mesquite or Salton Lake, can be drained into these lower levels, and in many other places wells may be put down to provide an outlet of drainage water into the great body of ground water which lies from 20 to 50 feet below the surface. Though required for the best growth and successful fruiting of the date palm, drainage is less necessary than for most other trees. Even if the ground water of the Salton Basin rose to within reach of the roots it would not kill the date palm, for, although this ground water is very brackish, containing from 0.4 to 0.6 per cent of dissolved salts, and would kill most ordinary plants, it is less alkaline than some of the artesian water used to irrigate flourishing date plantations in the Oued Rirh country in the Sahara (see pp. 86 and 121).

EFFECTS OF ATMOSPHERIC HUMIDITY AND RAIN ON THE DATE PALM.

An essential requirement of the date palm, in order that it may produce fruit of the best quality, is that the air be very dry during the season when the fruit is developing. Regions having abundant summer rains, and even those having a heavy precipitation in autumn, are unsuited to the profitable culture of this tree, but rains in winter may be beneficial. It has usually been held that the presence of humidity in the air is directly disadvantageous, but it is probable that the chief action of water vapor in the atmosphere is indirect and results from its peculiar action in screening out the heat from the sun's rays[a] and thereby preventing the temperature from going to the excessively high degree necessary to ripen the fruit properly. The same dry air which allows excessive heating during the day permits an equally great fall of temperature by radiation into a cloudless sky at night and brings about the enormous daily range of temperature characteristic of desert regions. The date palm, however, suffers no check from cool nights, unless the temperature falls below a point somewhere about 18° C. (64.4° F.), and is favored by excessively high temperatures, which are, indeed, necessary for the production of dates of the highest quality.

Table 1, on the following page, gives the mean relative humidity at four points where the date palm is grown, for the months of April to September, inclusive.

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[a] Very, Frank W. Atmospheric Radiation. Bul. G, Weather Bureau, U. S. Dept. of Agriculture, 1900.

TABLE 1.—*Humidity of the air at four desert stations where dates are grown.*

Locality.	Altitude.	Mean relative humidity of six months, Apr. 1 to Sept. 30.	Mean relative humidity of driest month.	Remarks.
	Feet.	*Per cent.*	*Per cent.*	
Ghardaïa, Algeria	1,804	23	14 (July)	Dates are of excellent quality.[1]
Biskra, Algeria	449	30	25 (June)	Dates are largely grown, but are not of the best quality.[2]
Phoenix, Ariz	1,068	33	24 (June)	Dates of the earlier sorts ripen well.[3]
Tucson, Ariz	2,432	35	19.9 (June)	Dates ripen imperfectly here, probably because of deficient summer heat at this altitude; possibly also because of too great humidity.[4]

[1] Records of Dr. Amat for the years 1883, 1888, and 1889.
[2] Schirmer, Sahara. p. 64.
[3] Records of Weather Bureau Station, completed by A. J. McClatchie, Bul. 37, Ariz. Agr. Ex. Sta., p. 209, average of five years' record.
[4] Boggs and Barnes, Bul. 27, Ariz. Agr. Ex. Sta., p. 37, record for the years 1892–1894. The mean for October is 36,3 per cent.

The following averages show the amount of atmospheric humidity at Phoenix and Tucson, Ariz., for each month from the flowering to the ripening of the fruit of the date palm, and a partial record from Ghardaïa, Algeria:

TABLE 2.—*Mean relative humidity at desert stations during date season.*

Locality.	Length of record.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Average, April to November.
Phoenix	5 years	33.0	26.0	24.0	37.0	40.0	39.0	40.0	43.0	35.25
Tucson	3 years	28.1	25.5	19.9	42.8	51.8	39.6	36.3	40.2	35.52
Ghardaïa	1 year (1883)	28.1	37.5	32.3	11.9	14.4	22.1			
Do	3 years			23.0	14.0	19.0				

The occurrence of a well-defined rainy season in July and August in southern Arizona causes the humidity for those months to be much higher than it is in the Sahara, where all three summer months are very dry.

The following table showing the average rainfall for each month at Biskra and Ayata in the Sahara, at Phoenix and Yuma, Ariz., and at Salton, in the Salton Basin, California, brings out this difference in climate:

TABLE 3.—*Mean monthly rainfall, in inches, at Biskra, Ayata, Phoenix, Yuma, and Salton.*

Locality.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
Biskra, Algeria[1]	0.52	0.64	1.38	0.94	0.83	0.33	0.25	0.26	0.57	0.64	0.93	2.17	9.46
Ayata, Algeria[2]	.08	.27	1.06	1.06	.16	0	0	0	.04	.12	1.21	.53	4.53
Phoenix, Ariz.[3]	.57	.89	.68	.30	.16	.07	.85	.97	.54	.62	.44	1.12	7.21
Yuma, Ariz	.40	.54	.24	.07	.04	T.	.14	.37	.14	.30	.28	.53	3.05
Salton, Cal.[4]	.43	.62	.21	T.	.07	T.	.19	.14	.13	.12	.12	.55	2.56

[1] Records of M. Colombo, published by Marcassin in Annales de l'Inst. Nat. Agronom., 1895, 10 years.
[2] Records of M. Cornu, read from charts exhibited at Paris Exposition, 1900, 4 years.
[3] Records of the Weather Bureau, compiled by Thos. H. Means, Second Rep., Div. of Soils, U. S. Department of Agriculture, 1900, p. 292.
[4] Records of the Weather Bureau, compiled by Prof. Alexander G. McAdie, California Climate and Crop Service, April, 1901, 12 years.

During July and August more than three times as much rain falls at Phoenix as at Biskra, although the annual rainfull is nearly one-third greater at the latter station.

Unfortunately records are not available for the Salton Basin, but the very low rainfall in spring, summer, and autumn, and the excessively high temperatures which prevail there render it certain that the humidity is very slight—probably somewhat lower than at Ghardaïa. There is, however, as in Arizona, a well-defined rainy reason in July and August, which tends to raise the humidity for those months.

RAINY WEATHER DISASTROUS TO THE FLOWERS AND RIPENING FRUITS OF THE DATE PALM.

Besides its indirect harmful action in decreasing the amount of sunshine and heat and in increasing the amount of humidity in the air, cloudy or rainy weather is directly injurious to the date in preventing the fertilization of the flowers in spring, and also in bringing about the decay or dropping of the fruit when it is ripening in autumn. When the flowers are being pollinated a spell of wet, cloudy weather, by spoiling the pollen may hinder the setting of the fruit, though usually the harm can be remedied by repollinating with a fresh spray of male flowers when the weather becomes dry. In autumn the effects of rainy, humid weather are much more disastrous and may entail the loss of the entire crop by causing the dates to ferment and spoil just when they are ripening. No misfortune is more feared by the date growers in the Sahara than wet weather at this time.

Most varieties of date palms flower in April and May in Arizona, as in the Algerian Sahara, and the best sorts begin to ripen in October and November. The following table shows the amount of rain for the months of April and May, in spring, and October and November, in autumn, for a number of points in the Southwest, and also for Biskra and Ayata in the Sahara.

TABLE 4.—*Average, highest, and lowest rainfall, in inches, at flowering and ripening seasons of the date palm at stations suitable for date culture.*

Locality.	Altitude.	Rainfall during flowering season. April. Mean.	April. Maximum.	April. Minimum.	May. Mean.	May. Maximum.	May. Minimum.
	Feet.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*
Phoenix, Ariz. (Salt River Valley)[1]	1,068	0.31	1.25	0	0.16	1	0
Buckeye (Salt River Valley)[2]	900	Tr.	....	....	.09	....	....
Experiment Farm (Salt River Valley)[2]	1,110	0	....	....	0	....	....
Peoria (Salt River Valley)[2]	1,200	.09	....	....	.18	....	....
Mesa (Salt River Valley)[2]	1,244	Tr.	....	....	0	....	....
Average for five stations in Salt River Valley	....	.08	....	....	.086	....	....
Maricopa, Ariz. (Upper Gila Valley)[2]	1,173	.13	.75	0	.10	.64	0
Casa Grande (Upper Gila Valley)[1]	1,398	.11	.73	0	.07	.34	0
Florence (Upper Gila Valley)[1]	1,553	.37	1.55	0	.18	.97	0
Tucson, Ariz.[1]	2,430	.16	.62	0	.18	1.09	0
Yuma, Ariz.[1]	141	.07	.55	0	.04	.44	0
Mammoth Tank, Cal. (Salton Basin)[3]	257	.06	.80	0	.02	.30	0
Salton, Cal. (Salton Basin)[3]	−263	Tr.	.01	0	.07	.70	0
Biskra, Sahara[4]	449	.94	3.03	.08	.83	2.56	.04
Ayata, Sahara (Oued Rirh)[5]	100	1.06	2.24	0	.16	.47	0

Locality.	Rainfall during ripening season of late dates. October. Mean.	October. Max.	October. Min.	November. Mean.	November. Max.	November. Min.	Rainfall during year. Mean.	Max.	Min.	Length of record.
	In.	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*	*Years.*
Phoenix, Ariz. (Salt River Valley)[1]	0.50	2.80	0	0.44	1.66	0	7.08	12.83	3.77	15
Buckeye (Salt River Valley)[2]	.63	......	......	.42	......	......	6.60	......	......	....
Experiment Farm (Salt River Valley)[2]	.34	......	......	.48	......	......	7.01	......	......	....
Peoria (Salt River Valley)[2]	.92	......	......	.40	......	......	8.41	......	......	....
Mesa (Salt River Valley)[2]	.31	......	......	.46	......	......	5.52	......	......	....
Average for five stations in Salt River Valley	.54	......	......	.44	......	......	6.94	......	......	....
Maricopa, Ariz. (Upper Gila Valley)[1]	.28	1.51	0	.29	1.13	0	5.50	11.96	.38	18
Casa Grande (Upper Gila Valley)[1]	.32	1.31	0	.33	2.00	0	5.29	10.70	1.73	14
Florence (Upper Gila Valley)[1]	.63	1.80	0	.55	2.36	0	9.78	13.80	5.35	13
Tucson, Ariz.[1]	.53	2.24	0	.48	2.06	0	11.63	18.37	5.26	19
Yuma, Ariz.[1]	.30	1.70	0	.28	2.43	0	3.05	5.86	.74	19
Mammoth Tank, Cal. (Salton Basin)[3]	.12	.68	0	.14	.73	0	1.81	5.48	Tr.	23
Salton, Cal. (Salton Basin)[3]	.12	.93	0	.12	.71	0	2.56	11.19	Tr.	12
Biskra, Sahara[4]	.64	1.73	0	.93	1.97	.12	9.46	16.30	5.67	10
Ayata, Sahara (Oued Rirh)[5]	.12	.28	0	1.21	2.05	.02	4.89	9.32	2.52	[6]4 and 7

[1] Records compiled by Boggs and Barnes, Bul. 27, Arizona Experiment Station, Table XVI.
[2] Records compiled by Thos. H. Means, Field Operations Divison of Soils, U. S. Department of Agriculture, Second Report, 1900, p. 292.
[3] Records compiled by Alexander G. McAdie, Cal. Sec., Climate and Crop Service, Weather Bureau, February, 1901, p. 4.
[4] Records of Colombo, published by Marcassin, L'Agriculture dans le Sahara de Constantine, in Annales de l'Institut National Agronomique, 1895, p. 17 of reprint.
[5] Records of Cornu for years 1896–1899, read from charts exhibited at Paris Exposition, 1900.
[6] Annual rainfall for 1889 to 1891, from Rolland, Hydrologie du Sahara algérien, p. 415, is included n this table, making seven years in all.

These records show that the Salt River Valley, the upper Gila Valley, Yuma, and even Tucson, Ariz., have less rainfall at the critical periods for the date palm than occurs at Biskra, Algeria, where date culture is the principal industry. Yuma, in the Colorado River

Valley, in extreme southwestern Arizona, and especially Salton and Mammoth Tank, in the Salton Basin, in southeastern California, show decidedly less rainfall than occurs at Ayata, in the Oued Rirh country in the Sahara, where date culture is almost the sole industry and where the Deglet Noor variety is grown successfully. Even the maximum rainfall in exceptionally wet years in the Salton Basin does not equal[a] the average rainfall for these critical months at Biskra.

The number of rainy days, which is a matter of considerable importance in determining the suitability of climate to date culture, runs closely parallel to the amount of precipitation, as may be seen by comparing the following records for Biskra and Tucson with those given above for the rainfall:

TABLE 5.—*Number of rainy days at desert stations (Biskra, Algeria, and Tucson, Ariz.) during flowering and ripening seasons of the date palm.*

Locality.	Altitude (feet).	Length of record (years).	Flowering season.						Ripening season.					
			April.			May.			October.			November.		
			Mean.	Maximum.	Minimum.	Mean.	Maximum.	Minimum.	Mean.	Maximum.	Minimum.	Mean.	Maximum.	Minimum.
Biskra, Algieria..	449	10	3.4	7	1	3.5	6	1	2.6	5	0	3.6	7	1
Tucson, Ariz......	2,432	5	.2	1	0	1.2	3	0	4.8	9	0	.2	6	0

The ideal climate for the date palm would be one that was rainless during the critical months. It is a matter of some interest to see how often this condition has been recorded for the Salton Basin stations.

Rainfall records are available for twelve years (1889–1900) for Salton in the lowest part of the Salton Basin (263 feet below the sea level), and they show that the critical months were frequently rainless; at Mammoth Tank, in the eastern border of the Salton Basin (altitude 257 feet above sea level), the record for twenty-three years, from 1878 to 1900, is still more favorable, as is shown by the following table:

TABLE 6.—*Number of years in which no rain (or trace only) fell at Salton and at Mammoth Tank, in the Salton Basin, California, during the months named.*

Month.	Salton (263 feet below sea level).		Mammoth Tank (257 feet above sea level).	
	Number of years rainless.	Total number of years recorded.	Number of years rainless.	Total number of years recorded.
April........	11	12	14	23
May........	10	12	20	23
April and May........	9	12	13	23
October........	8	12	12	23
November........	8	12	13	23
October and November........	7	12	7	23

[a] Except for one year of the twelve recorded at Salton, the rainfall in October, 1896, was 0.93 inch, exceeding the average at Biskra (0.64 inch), though not being more than half the maximum rainfall for the month (1.73 inches) at the latter station.

At Salton, out of the twelve years recorded, only one had more than one-tenth of an inch of rain during the two months of the flowering season (April and May) and only two had over 0.28 inch rainfall during the ripening season.

At Mammoth Tank, out of these twenty-three years, only one had more than three-tenths of an inch rainfall during the flowering season (April and May) and only three showed over three-tenths of an inch precipitation during October and November.

At Biskra, in the Algerian Sahara, the rainfall records are available for the ten years from 1884 to 1893. During this period only one month during the critical periods was rainless, viz, October, 1893. Only once during the flowering period (April and May) was there as low as 0.39 inch rainfall, and only once during the season when the fruit ripens (October and November) was there as low as 0.31 inch of rain.

At Ayata, some 100 miles south of Biskra, in the Oued Rirh country, where a specialty is made of the culture of choice Deglet Noor dates for the export trade, the rainfall for 1889 was 2.52 inches; for 1890 it was 9.32 inches; for 1891,[a] 4.16 inches; for 1896, 7.60 inches; for 1897, 4.84 inches; for 1898, 2.79 inches, and for 1899,[b] 2.91 inches, an average of 4.89 inches.

The distribution of the rainfall at Biskra and Ayata, by seasons, in comparison with the average at Yuma in the Colorado River Valley and Salton and Mammoth Tank in the Salton Basin, is given herewith:

TABLE 7.—*Table showing seasonal and annual rainfall at stations in desert regions.*

Locality.	Length of record.	Winter rainfall.	Spring rainfall.	Summer rainfall.	Autumn rainfall.	Annual rainfall.
	Years.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*
Biskra, Algeria (Sahara)	10	3.32	3.16	0.84	2.13	9.45
Ayata. Algeria (Sahara)	7	1.81	1.49	[a].09	1.50	4.89
Yuma, Ariz. (Colorado River Valley)	19	1.47	.35	.51	.72	3.05
Salton, Cal. (Salton Basin)	12	1.59	.28	.33	.37	2.56
Mammoth Tank, Cal. (Salton Basin)	23	.93	.27	.29	.32	1.81

[a] During the years 1896 to 1899 almost no rain fell in summer. April, May, September, and October are sometimes rainless.

It is noticeable that the summer rainfall is considerably higher at Yuma and at the Salton Basin stations than at Ayata, but that the spring and autumn precipitation is much less, rendering the climate decidedly more favorable for date culture.

It is clear from the above tables that there is less danger from rain to date flowers or to the ripening fruits in the Arizona deserts or in the Salton Basin in California than at Biskra in the Algerian Sahara, where date culture is an established and profitable industry. Indeed,

[a] Rolland. Hydrologie du Sahara, p. 416. For the years 1889 to 1891, inclusive.

[b] Records of Cornu exhibited at Paris Exposition, 1900. Amounts read from curves of charts for the years 1896–1899.

than on the tops of old palms far above the surface. Old and vigorous trees might perhaps occasionally weather cold snaps where the temperature fell below 10° F., provided such were exceptional and occurred only at intervals of many years. In practice, then, four different limits below which palms would be injured by cold might be set: (1) Young palms in active growth would be liable to injury if the temperature fell several degrees below freezing; (2) young plants not in active growth and old palms if nearly dormant would be severely injured only by temperatures falling below 15° F.; (3) old and dormant trees would be severely injured only by temperatures below 12° F.; (4) most date palms would be killed and all would be seriously injured by the temperature falling below 10° F., and date culture would be impossible in regions where such temperatures occurred more than once in a decade. These considerations show that the date palm has about as much resistance to cold as the fig tree, for example, with this important difference—that a fig tree is able to recover and grow again the next year, even if it be frozen to the ground by severe cold in winter. With the date palm this is not possible, since, if the growing bud of an old tree be killed, it is impossible for the trunk to sprout out again.

In the Salt River Valley, Arizona, the temperature not infrequently falls to 25° or 22° F., and at rare intervals goes as low as 12° or 13° F., which temperatures of course injure the date palm but have not killed any of the many fine trees growing in the valley, though young offshoots recently transplanted have been frozen to death[a].

No temperatures low enough to injure seriously even young date palms (below 18° F.) are recorded from any of the stations in the Salton Basin,[b] and if the first winter after the plants are set out is passed safely no further danger from cold need be feared.

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[a] Even young palms seem more resistant to cold than has been supposed, for the severe cold of the winter of 1901-2, when a temperature of about 13° F., was reached, killed very few of the Saharan date palms in the cooperative garden at Tempe, which were planted in July, 1900. A few of the offshoots set out in 1901 passed through the cold weather without being killed, thanks probably to the protection afforded by wrapping them in several thicknesses of burlap sacking. It is now very clear that large offshoots withstand cold much better than small ones and besides bear the long voyage better.

[b] The lowest temperature recorded at Salton is 20° F., with 22° F. at Mammoth Tank, where only 9 out of the 23 years recorded show temperatures below 30° F. At Indio in the northern and at Imperial in the southern part of the basin temperatures of 18° F. are recorded. At Indio the temperatures are probably lowered by cold winds which blow down from the mountains to the north and west through a valley-like prolongation of the desert to the northwest. The young date palms which grow about Indio without any protection are proof that the winters are not too severe even for very young plants. However, winter cold is the greatest danger to which the date palm is exposed in the Salton Basin, and intending planters should be careful to avoid low, cold situations in setting out date palms, for Snow reports on January 2, 1902, at 8 o'clock a. m., a temperature of 13° F. and ice 2 inches thick. (Bul. 140, Cal. Exp. Sta., p. 45.) A. V. Stubenrauch states that this record is for Imperial, Cal.

THE DATE PALM FLOWERS LATE IN SPRING AND ESCAPES INJURY BY LATE FROSTS.

A very great advantage of the date palm is that it flowers late in spring, after all danger of frost is over,[a] whereas many other fruit trees, among them the peach, the apricot, and especially the almond, bloom very early and are exposed to much risk of having the flowers or young fruits killed by late frosts.

The records available from the Sahara are very poorly calculated to show how much cold the date palm can stand, for the whole northern and western Sahara is characterized by very warm winters. Temperatures of -5 to $-7°$ C (21.4° to 23° F.) are recorded from date oases in the Sahara, but the date palm is able to endure lower temperatures than these without serious harm resulting. The northern limit and the limit in altitude in northwestern Africa at which dates can be grown are set more by the deficient summer heat failing to ripen the fruit than by the cold in winter.[b]

DRAINAGE OF COLD AIR AND INVERSION OF TEMPERATURE IN RELATION TO DATE CULTURE.

A peculiarity of climate which is of considerable importance in relation to date culture is the inversion of temperature which occurs in many places in Arizona and California, and more markedly in arid regions where the date palm succeeds best. For example, in many parts of Arizona the winters are mild enough to permit date palms to be grown at an altitude of nearly 5,000 feet, and even as high as 6,942 feet at Supai. It is noticeable, however, that points very much lower frequently show temperatures sufficiently cold to injure severely or to kill date palms. For instance, at San Carlos, at an altitude of 2,456

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[a] The pistache nut has the same advantage and can be grown with profit in place of the almond in many localities where the latter is likely to lose its fruit because of late frosts.

[b] It is probable that the date palm is hardier than has been supposed, and that by selecting hardy sorts and wrapping them well when young, date culture can be extended to many of the desert regions in the Southwest hitherto supposed to be too cold in winter for this plant. The experiments at the date garden at Tulare have shown that there is a great difference in the resistance of the various sorts to cold, the Seewah at an age of 9 years being, for instance, 12 feet high, with a spread of leaves of 15 feet, while the Sultaneh, equally old but which had been much hurt by the cold winters was only 4 feet high, with a spread of leaves of 7 feet. The experience of the winters of 1901-1902 at Tempe, Ariz., has shown that recently transplanted offshoots are hardier than has been supposed. It now becomes a matter of much importance to procure hardy sorts of date palms (probably best to be secured in the oases of Persia and Baluchistan) for planting in the deserts in the southwestern United States which have hot summers but cold winters. Fort McIntosh, altitude 460 feet, in southwestern Texas, and Fort Thomas, altitude 1,600 feet, in the valley of the Virgin River in southern Nevada, both have a summer climate hotter than that of Phoenix, in the Salt River Valley, Arizona, but at the same time colder winters. Late sorts of dates of good quality could be matured at these places provided they could pass the winters unharmed (see pp. 126 and 134).

feet, and at Tucson, at the University weather station, at an altitude of 2,230 feet, the temperature fell to 11° F. in 1891, while at Dragoon Summit, at about 4,611 feet altitude, some 60 miles to the east of Tucson and 80 miles southwest of San Carlos, the temperature is not recorded even as low as 15° F. in 1891.[a] In January, 1891, the temperature did not fall below 32° F. at Dragoon Summit, while at Wilcox, only 20 miles northeast, and nearly 500 feet lower, the temperature fell to 9° F. A still more striking example is shown by a comparison of the temperatures at Parker, on the Colorado River, at an altitude of about 500 feet, and at Supai, nearly 7,000 feet above sea level, some 120 miles to the northeast. In the winter of 1899 and 1900 the temperature did not fall below 26° F. at Supai, while the imperfect record at Parker shows a minimum of 23° F., that is to say, that although Supai is nearly 6,500 feet higher than Parker and is about 65 miles farther north, the minimum temperature was actually higher at Supai in winter. Numerous similar instances could be cited in California, and the "thermal belt" along the foothills of the Sierra Nevada Mountains, adjoining the interior valley region, offers some of the most striking examples that are known of inversion of temperature.

All of these anomalies are the result of a drainage of cold air to lower levels. During the night, if radiation is unhindered by clouds, as is usually the case in arid regions, the air next the ground is cooled rapidly and flows from the higher levels into the valleys below, much as water would. As the cold air flows into the plains it doubtless tends to flow under and to lift up the warm air; at any rate, all elevated points where there is a good drainage of air show relatively high temperatures during the night, while points located in the valley floor frequently show very low temperatures, constituting an exception to the general rule that the lower the altitude the higher is the temperature. It will frequently be possible to grow date palms along the foothills where it would be impossible for them to succeed in the plains a few hundred feet below.

However, high summer temperatures are essential to the proper fruiting of the date palm, as will be shown in the next paragraph, and the upper limit in altitude of its culture is more likely to be set by the insufficient heat of summer than by the severity of cold in winter. At points situated at high altitudes, whence there is a good drainage of air, the fluctuations of temperature are less than in the plains below, and consequently the winters are warmer and the summers are cooler. In order to grow date palms at high altitudes, it will usually be necessary to search for canyons or ravines with a southern exposure, where the air is heated by reflection from mountain cliffs as well as by direct insolation.

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[a] All the data as to temperature at the various points named are from the reports of the Weather Bureau and of the State weather services of California and Arizona.

HOT SUMMERS NECESSARY FOR THE DATE PALM.

Date palms require a definite sum of heat in order to mature their fruit properly, but the amount varies greatly for different sorts. In general the very early ripening kinds are watery and unfit for drying, being more like table grapes than like ordinary dates. They can be grown far to the north where the summers are not warm enough to ripen later varieties. The Wolfskill is such a date (see fig. 3, p. 31). The sorts ripening in midseason can often be dried, but lack the sweetness and exquisite flavor of the late sorts, such as the Deglet Noor (see p. 33). The late sorts, and especially the one just named, require enormous amounts of heat in order to ripen properly. The Deglet Noor date is produced in the oases of southern Algeria and southern Tunis, where fortunately there are well equipped meteorological stations whose records furnish a basis for a comparison of the climate there with that of American deserts, so far as records are available for the latter.

It has been calculated by De Candolle[a] that temperatures down to 18° C. or 64.4° F. have no effect on the flowering or fruiting of the date palm, and a study of the record sheets of a self-recording thermometer kept at Biskra in the midst of a date orchard confirmed the correctness of this assumption. In other words, this relatively high temperature is the zero point for this plant, so far as flowering and fruiting are concerned, though it is able to grow at somewhat lower temperatures. The curves shown in the accompanying diagram (fig. 7) represent in a manner plain to the eye the heat conditions of Biskra, Algeria, in the northern part of the Sahara Desert, in comparison with those of Salton, in the lowest part of the Salton Basin.[b]

The curves highest up in the diagram represent the mean maximum temperatures, the curves in the middle show the mean temperatures

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[a] Géographie botanique raisonnée, I, p. 371.

[b] The curves for Biskra for maximum and minimum temperatures are based on averages of twelve one-half years' observations by M. Colombo, summarized by Supan (Petermann's Mitth., Vol. 32, 1886, Lit. ber., p. 32); for the mean temperature, on ten years' observations by Colombo, published by Marcassan (Ann. de l'inst. nat. agronom., Paris, 1895). The curve for the maximum temperature for Salton is based on the record for two selected years, 1893 and 1899, each having nearly the same sum of heat for the fruiting season, from May to October, inclusive, as the average of the twelve years recorded. Prof. Alexander G. McAdie, director of the Pacific coast division of the Weather Bureau at San Francisco, kindly furnished the records, as yet unpublished, for these years. This curve is smoothed a little and is somewhat lower than the true mean maximum, as it is based on observations taken at 2 o'clock p. m., which do not always give the highest temperature which occurs during the day. The curve for the mean temperature at Salton is based on twelve years' observations published by Professor McAdie. (California Section, Climate and Crop Service, Weather Bureau, February, 1901, p. 4.) The curve for the minimum temperatures for Salton is not based on any observations, as the minimum temperatures are not available; the mean minimum temperatures are estimated to be as far below the mean temperatures as the mean maximum temperatures are above.

of the whole day, and the curves lowest in the scale show the mean minimum temperature. In every case the dotted lines represent the record for Biskra and the unbroken lines that for Salton. The months of the year are marked off horizontally and the degrees of heat are shown by the height of the curve from the base. The temperatures can be read off in Fahrenheit at the left and in Centigrade at the right. The heavy black horizontal line represents the zero point for the flowering and fruiting of the date, 18° C. (64.4° F.).

It is evident from the first glance at the curves that Salton is much hotter than Biskra and that the daily range of temperature is much greater, and as a consequence that the mininum is lower in winter, at the same time that the mean temperature is higher.

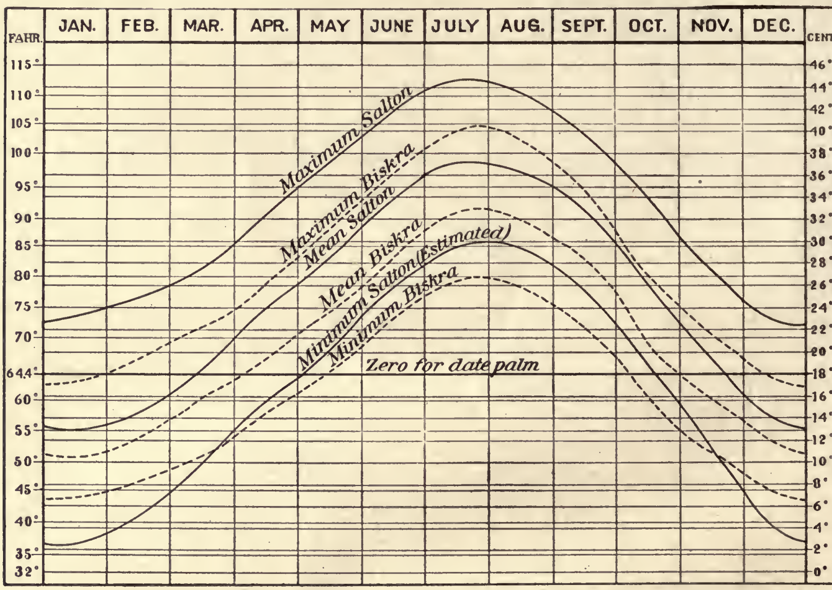

FIG. 7.—Curves representing the average maximum, mean, and minimum temperatures at Salton, Cal., and at Biskra, Algeria.

The zero point for the date palm, 18° C. (64.4° F.), is reached by the mean temperature about April 5 at Biskra, while it is passed fully three weeks earlier at Salton, or about March 12. The mean daily temperature rises more rapidly at Salton than at Biskra, which brings about the result that the period when the date palm flowers, which according to Fischer's calculations[a] is when the mean daily temperature is between 20° and 25° C. (68–77° F.), extends from about April 20 to May 20 at Biskra, whereas at Salton it extends from about March 23 to April 20; that is to say, if Fischer's calculations are correct, the date palm will flower about a month earlier at Salton than at Biskra,

[a] Fischer, Th. Die Dattelpalme, ihre geographische Verbreitung und culturhistorische Bedeutung. In Petermann's Mitth., Ergänzungsheft No. 64, Gotha, 1881, p. 51.

although the zero point for this plant is passed by the mean temperature only three weeks earlier.

The mean temperature at Biskra usually remains above 18° C. (64.4° F.) from about April 5 until about November 3, some 212 days, or nearly 7 months. At Salton the period having a mean temperature above 18° C. extends from about March 12 until about November 20, or some 253 days, nearly six weeks longer than at Biskra. As has been already stated, the flowering season will probably begin a month earlier at Salton than at Biskra because of the abrupt rise of temperature in spring, and as the mean temperature remains above 18° C. (64.4° F.) nearly a month and a half longer in autumn, the season is nearly two months and a-half longer, and, moreover, is decidedly hotter throughout. It is evident that if the Deglet Noor date can mature at Biskra it can certainly ripen perfectly at Salton.

AMOUNT OF HEAT REQUIRED TO MATURE THE DATE.

The comparison of the sums of the daily mean temperatures generally employed in determining the heat requirements of plants can be made only between regions having a somewhat similar climate, and some botanists have gone so far as to deny entirely that any trustworthy conclusions as to the development of a plant can be drawn from estimates of its heat requirements. To say that the sum of heat decides when a plant flowers or when its fruits ripen has been held to be equivalent to asserting that the other factors of equally vital importance to the plant, such as the amount and nature of its food supply, the supply of water, the amount of light, etc., have no appreciable influence on its development. This criticism doubtless has much force in the case of humid regions, where a variable and capricious rainfall greatly influences the growth of vegetation. In rainless deserts, however, where all cultivated plants are watered artificially and where the sunshine is almost uninterrupted by clouds, the sum of heat becomes a factor of predominant importance in the life history of plants, and consequently comparisons between similar desert regions in respect to their adaptability for any given cultures may very properly be made by determining the sum of heat for the critical periods of the plants in question.

The amount of heat necessary to ripen the fruits of the date palm has generally been calculated by adding together the daily mean temperatures during the months when the dates are developing, generally from about May 1 until October 31, six months in all. In this bulletin the sum above 18° C. is counted for greater convenience in making comparisons, though generally the sum is reckoned from 0° C. The table on the following page gives the summation of effective temperatures during the fruiting season of the date palm for a number of points in North Africa and in the Southwestern States.

TABLE 9.—*Sum of daily mean temperatures above 18° C. (64.4° F.) for fruiting period of date palm from May 1 to October 31, at the stations named.*

Locality.	Sum of daily mean temperatures above 18° C. (64.4° F.) from May 1 to October 31.		Remarks.
	Degrees centigrade.	Degrees Fahrenheit.	
Algiers, Algeria	652	1,174	No dates ripen here.
Orléansville, Algeria	788	1,418	Very early sorts mature.
Fresno, Cal	1,054	1,897	Average of many years' observations. Dates of sorts grown usually fail to ripen.
Tucson, Ariz	1,409	2,538	Average of 6 years' observations. Dates of the sorts now grown usually fail to ripen.
Cairo, Egypt	1,593	2,868	Dates ripen regularly.
Phoenix, Ariz. (Salt River Valley).	1,677	3,019	Average of many years' observations. Many sorts of dates ripen regularly.
Biskra, Algeria (Northern Sahara).	1,836	3,304	Average of 10 years' observations. Many sorts of dates ripen regularly; date culture the leading industry. Deglet Noor dates ripen but are not of the best quality.
Ayata, Algeria, 1890 (Oued Rirh region), Sahara.	1,816	3,269	Deglet Noor dates ripened very imperfectly.
Ayata, 1891	1,906	3,431	Deglet Noor dates ripened very slowly and imperfectly.
Ayata, 1889	2,091	3,764	Deglet Noor dates ripened well.
Tougourt, Algeria (Oued Rirh region).	2,049	3,689	Do.
Bagdad, Mesopotamia	2,356	4,242	Average of 5 years' observations. Many excellent varieties ripen.
Indio, Cal. (Salton Basin)	2,237	4,027	Average of several years' observations.
Indio, 1903	2,348	4,227	New thermometers.[1]
Mammoth Tank, Cal. (Salton Basin).	2,585	4,652	Average of 23 years' observations.
Salton, Cal., 1903 (Salton Basin).	2,074	3,734	The coolest summer recorded. Observations taken for the first time with standard Weather Bureau thermometers in the regulation shelters.[1]
Salton, mean	2,679	4,823	Average of 12 years' observations.
Salton, 1897	3,392	6,106	Hottest summer recorded at Salton.
Salton, 1902	2,749	4,948	
Imperial, Cal., 1902 (Salton Basin).	2,106	3,791	

[1] Until 1903 the temperature records in the Salton Basin were taken by voluntary observers from thermometers exposed without proper shelters. Mr. Bernard G. Johnson, who lives in the Salton Basin between Salton and Indio, Cal., writes as follows:

"Formerly there were used cheap thermometers, placed at Indio in the shade of cottonwood trees, at Salton under an overlapping roof, and at Volcano Springs under a roof that was but slightly overlapping. Now they have standard thermometers placed in regulation thermometer shelters, and hence the difference."

As might be expected, the older records taken at Volcano Springs proved to be much too high, at Salton still too high, though somewhat nearer normal, and at Indio normal or somewhat too low when compared with the records taken in 1903 with properly protected thermometers.

Station.	Month.	Mean temperature for 1903.	Departure from normal average.	Station.	Month.	Mean temperature for 1903.	Departure from normal average.
		°F.	°F.			°F.	°F.
Volcano Springs	April	69.4	−9.5	Indio	June	91.1	− 2.8
Salton	...do	72.6	−3.9	Volcano Springs	July	90.9	−10.4
Indio	...do	72.6	+0.1	Salton	...do	87.8	−11.1
Volcano Springs	May	78.5	−8.3	Indio	...do	94.4	− 0.1
Salton	...do	79.1	−4.0	Volcano Springs	August	95.2	− 3.5
Indio	...do	81.0	+0.9	Salton	...do	94.2	− 3.0
Volcano Springs	June	88.5	−7.9	Indio	...do	93.1	− 0.1
Salton	...do	89.4	−4.4				

Mr. Johnson queries: "If this year, for example, May was 8.3 degrees cooler than the average at Volcano, why was it only 4 degrees cooler at Salton, 24 miles west of Volcano and at the level of the valley, while it was 0.9 degree warmer 24 miles farther west at Indio?"

Nevertheless, the sum of the daily mean temperature from May 1 for 1903 was still enough to mature the Deglet Noor date perfectly.

A further proof of the greater sum of heat in the Salton Basin, as compared with the Salt River Valley, is given by Mr. Johnson, who states that cantaloupes ripen at least fourteen days before the Salt River Valley melons at Mesa, Ariz., and that, too, before the really hot weather begins, which occurs about the first week in June. Mr. Johnson observes that if the same proportion continues, the growing season up to November 1 would give about six weeks advantage over Salt River Valley. Now the Deglet Noor date nearly matures at Tempe in the Salt River Valley and will surely ripen where it will receive such a considerable sum of heat more than in the Salt River Valley.

The records taken at Ayata,[a] Algeria, in the Oued Rirh country, are of particular interest. The Deglet Noor date is there grown largely for export and the meteorological observations are taken in an oasis largely planted to this variety. Even here in the interior of the Sahara Desert (see map, Pl. II, p. 76) the summers are frequently too cool to permit this choice date to ripen properly. From three years' observations it is considered that about 2,000° C. are required to ripen the Deglet Noor date satisfactorily. At Biskra the Deglet Noor is grown, but does not attain the superatively good quality which has made the dates of the Oued Rirh famous.[b] It will be noticed that Phoenix is somewhat cooler than Biskra, making it doubtful whether this date will ripen there in ordinary seasons. On the other hand, there can be no doubt about the Salton Basin stations being hot enough to bring Deglet Noor dates to maturity, even at Indio, in the northern edge of the basin, and at Imperial, while at Salton the sum of heat during the coolest summer recorded there was greater than the average sum for Tougourt, and almost the same as the maximum sum for an exceptionally hot summer at Ayata, when the Deglet Noor matured perfectly. *There can then be no doubt that the Deglet Noor date will ripen fully in the Salton Basin, even when the season is exceptionally cool.* The importance of this demonstration can scarcely be overestimated, since it renders it possible to establish in America the culture of this choice date, the most expensive of dried fruits, with certainty of success.

The date palm requires very high temperatures, very much higher than those recorded by thermometers exposed in the shade, and to measure accurately its heat requirements it will probably be necessary to devise a thermometer which can be exposed to the sun and which will indicate the temperature reached by the leaves. Accordingly a summation of the maximum temperature was made for the days from May 1 to October 31, which it is thought will give a better idea of the adaptability of a climate for date culture than does the sum of the daily mean temperatures. In making this summation 18° C. (64.4° F.) was taken as the zero point, as in the preceding table, and when the daily minimum fell below that point a deduction was made for the temperatures below the zero point, where they were considered as being a setback[c] and as preventing the observed maximum temperature from causing the growth or development it would otherwise have done.

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[a] Rolland, Georges. Hydrologie du Sahara algérien, p. 416.

[b] In the oasis of Chetma, near Biskra, the Deglet Noor date is said to ripen perfectly, thanks to the warm spring water with which the oasis is irrigated (see p. 49).

[c] For example, the mean maximum for October at Biskra is 27.4° C., or 9.4° above 18° C.; the mean minimum is 16.2° C., 1.8° below 18° C. Now 9.4° is 83.93 per cent of the total daily range of 11.2°, and so instead of counting $31 \times 9.4 = 291.4°$ as the sum for the month, only 83.93 per cent of this sum is counted, or 244.57° C.

The following table gives the results of such a summation of mean maximum temperatures from a number of points where date palms grow or can be grown:

TABLE 10.—*Sum of daily maximum temperatures above 18° C. (64.4° F.) for date season, May to October, inclusive, at the stations named.*

Locality.	Sum of daily maximum temperatures.		Remarks.
	Degrees centigrade.	Degrees Fahrenheit.	
Algiers, Algeria	1,482	2,667	No dates ripen. Records by Angot (Météor. Algér.).
Fresno, Cal	2,002	3,604	Very early dates can ripen. Weather Bureau records, 1897–1900.
Laghouat, Algeria (extreme northern Sahara).	2,337	4,243	Date culture practiced, but dates inferior. Records by Angot.
Orléansville, Algeria	2,593	4,668	Early sorts can be matured. Records by Angot.
Tucson, Ariz	2,652	4,773	Early sorts can be matured. Records of University of Arizona, 1892–1897.
Biskra, Algeria (northern Sahara).	3,049	5,489	All sorts of dates grown. Deglet Noor dates not of best quality. Records of Colombo for 12½ years.
Phoenix, Ariz. (Salt River Valley).	3,068	5,523	Many seedling dates mature; some sorts are too late to ripen fully. Records of Weather Bureau, 1897–1900.
Ayata, Algeria (Oued Rirh, Sahara).	3,295	5,932	Deglet Noor matures well if summers are hot; ripens imperfectly during cool years. Records of Cornu for four years, 1896–1899, read from charts exhibited at the Paris Exposition, 1900.
Tougourt, Algeria (Oued Rirh, Sahara).	3,666	6,599	Deglet Noor dates are grown for export. Records of Angot.
El Golea, Algeria (interior of Sahara).	3,990	7,182	Interior of Sahara, one of hottest stations known. Dates are extensively grown. Records from Toumey, Bul. 29, Arizona Agr. Exp. Sta.
Bagdad	3,898	7,017	Average of 5 years' records, published by Willcocks. (Fairchild, Bul. 54, Bureau of Plant Industry, U. S. Dept. of Agriculture, 1903, p. 10.)
Salton, Cal. (Salton Basin)	4,059	7,306	Unpublished records for 1893 and 1899 furnished by courtesy of Prof. Alex. G. McAdie. These years have the temperatures for the summer season closely approximating to the average for 12 years recorded.
Salton, 1902	4,010	7,218	Record for 1902 supplied by courtesy of Prof. Alex. G. McAdie.
Imperial, Cal., 1902 (Salton Basin).	3,931	7,077	Do.

It is remarkable how nearly alike the sums of the daily maximum temperatures are for Salton and Imperial for 1902 when we consider how different the sums of the daily mean temperatures are, (See Table 9, p. 66). If the records for 1902 are correct at both points it would indicate a noteworthy difference in climate, the maximums being proportionally higher at Imperial than at Salton. These sums of temperatures show that the Deglet Noor date is certain to mature fully at Imperial, in the heart of the irrigated portion of the Salton Basin; this is indicated not only by the sum of the daily mean temperatures, but still more clearly by the sums of the daily mean maximum temperatures during the fruiting season.

It is worthy of note that by this system of calculating the sum of heat is higher at Phoenix than at Biskra, whereas the order was reversed when a summation of the mean daily temperature was made (see Table 9, p. 66). This result leads one to hope that the Deglet

Noor may after all ripen in the Salt River Valley. By this method of calculating, as well as by the summation of the mean temperatures, Salton heads the list, being the hottest desert station known.[a] There can be no question that the Deglet Noor and other choice late sorts will mature here and in the other parts of the Salton Basin.

The advantages of excessively hot summer climates for date culture are demonstrated in the Souf country in the Sahara, a region covered with large dunes, sometimes 500 feet high, of wind-blown sand (Pl. II, p. 76), lying about 50 miles east of the Oued Rirh and probably having about the same summer climate as Ayata and Tougourt. The best Deglet Noor dates are said to come from the Souf and are grown in peculiar sunken gardens excavated to a depth of from 25 to 30 or even 50 feet. These sunken gardens, called "Ghitan" or "Rhitan" (see fig. 8), are dug down to within a few feet of the level of the ground water

FIG. 8.—Sunken date gardens in the sand dunes in the Oued Souf region, near El Souf, Algeria.

and are large enough to contain from 6 to 100 palms, usually from 25 to 50. The sides are sloping, and composed of sand which reflects the sun's heat and light on the leaves from the sides and from below, thus intensifying the heat to such a degree that even the Arabs can not work in these gardens during the hottest weather.[b] In these torrid gardens the space is so valuable that the palms are not allowed to pro-

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[a] See footnote, p. 66.

[b] No irrigation is necessary for the date palm in these gardens, as the roots reach the moist sand near the water level. The chief labor is the carrying out of the sand blown in by the wind. When the hot simoon winds of summer blow, the natives do not attempt to work during the day but commence after midnight when the temperature is lowest. So difficult is the struggle against the sand blown into the gardens by every high wind that their labor has been likened to that of ants rather than that of men.

duce offshoots, which are imported from the Oued Rirh country when needed to plant new gardens. A single palm may be worth from $80 to $100 and may produce as much as 330 pounds of dates, which bring the highest price of any in the Sahara. There can be little doubt that the superior quality of these dates is due to the accumulation of heat in the still air of the sunken gardens by reflection from the bare sand of the sloping sides.

In the Salton Basin the Deglet Noor date can doubtless attain the same perfection with infinitely less expense and trouble, since the higher summer temperature will give the same heat in level orchards that is reached in the sunken gardens of the Souf.

EFFECTS OF WIND ON THE DATE PALM.

In the large deserts there are frequently high winds which are usually very hot and dry and sometimes so violent as to carry great quantities of dust and sand. Delicate foliage is injured by such winds in two ways; first, by being lacerated by the violence of the wind and also bruised and abraded when sand is carried; second, by the drying action of the intensely hot, dry air, especially on leaves which have been torn or injured. Such winds often cause great discomfort and even grave danger to caravans in the desert. "The spectacle is frightful, the impression most painful, the danger real; sand obscures the air and singes the face, it fills the eyes, the mouth, the ears; it hurts the throat and dries up the water skins of the native caravans, which are thereby in danger of perishing."[a]

Such winds, called "simoons" or "siroccos" in the Sahara, often blow several days in succession, sometimes keeping up all night. During such winds the relative humidity sometimes falls as low as 2 per cent at a temperature of 33° C., corresponding to 0.75 mm. pressure of water vapor,[b] whereas the mean humidity of the driest month at Paris, for example, is 57 per cent, and at Biskra 25 per cent (see p. 53).

Observations made by the writer at Biskra during a sirocco at 3 o'clock p. m., May 13, 1900, showed even less humidity. The dry thermometer read 38.5° C. and the wet bulb sling thermometer 15.3° C., corresponding to a relative humidity of 2 per cent and an absolute pressure of water vapor of 1.02 mm.[c] Sometimes the air is so dry in the interior of the Sahara that the instruments such as have been used do not indicate the presence of any water vapor whatever.

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[a] Rolland, Georges. Géologie du Sahara algérien, p. 225.

[b] Massart, Jean. Un voyage botanique au Sahara. In Bul. Soc. Roy., Bot. de Belgique, vol. 37 (1898), I, p. 273, observations made near Ouargla at noon, May 23, 1898; the wet-bulb sling thermometer registered 14.2° C., which gives nearly 7 per cent relative humidity by Prof. C. F. Marvin's tables (Weather Bureau Publication No. 235, 1900).

[c] Calculated by Prof. C. F. Marvin, Weather Bureau, U. S. Dept. of Agriculture.

Such winds have no bad influence on the date palm, but on the contrary favor the proper maturing of the fruit in regions where the season is short and some oases in northern latitudes fail to produce a crop if the hot winds do not blow frequently.[a] The date trunk is so strong and elastic and so firmly attached by the cord-like roots that it is an extremely rare occurrence for a palm to be broken or blown over by the heaviest gales, although the crown of leaves at the top of the slender stem exposes the trunk to the greatest possible strain. The leaves are very tough and strong and are very seldom torn by the wind or bruised by sand. The only harm heavy windstorms do is to interfere with the setting of the fruit by blowing the pollen away. This injury can usually be remedied by repollination after the storm is over. In the Salt River Valley, at Tucson, and at many other points in southern Arizona, the average wind velocity is low and wind storms are infrequent, so the date palm has in these regions no particular advantage over other plants because of its ability to support wind and sand storms. In the Salton Basin, however, the case is different, as rather heavy winds are not uncommon, and dust and sand are often carried in considerable amounts. These winds are, however, certainly not so severe as in the Sahara and will in no way interfere with successful date culture.

It seems, however, that in the great date region about Bassorah, at the head of the Persian Gulf, the "shamel," or hot wind laden with dust, may do great damage. Mr. Fairchild states[b] that "if this (shamel) occurs before the dates have sufficiently matured it dries them up and covers them with dust, checking their development and soiling them so that they are refused by the European and American importers. Last year's crop (1901) was seriously injured in this way, and the export was reduced from nearly 2,000,000 cases to about 1,000,000."

It is conceivable that the enormous losses occasioned in the Bassorah region by hot, dust-laden winds, which are nowhere else reported to have so deleterious an action, may be due to the peculiar character of the climate at the head of the Persian Gulf. The proximity of the sea causes the humidity to be much greater here than in most date-growing regions, and this unusual humidity may perhaps render the developing dates peculiarly susceptible to injury by desert winds, possibly by rendering their surface sticky and thereby causing the dust carried by the wind to adhere to them.

The cold northwest winds which often blow for several days at a time during the winter and spring in the Algerian Sahara[c] and the

[a] At the oasis of Khabis in Persia dates do not ripen well unless the hot, dry, desert wind blows at least forty days during the summer. Abbot, cited by Fischer, Die Dattelpalme, p. 55.

[b] Fairchild, D. G. Persian Gulf Dates and Their Introduction into America. Bul. 54, Bureau of Plant Industry, U. S. Department of Agriculture, p. 28, 1903.

[c] Rolland, Georges. Hydrologie du Sahara algérien, p. 416.

cold north and east winds in southern Tunis[a] are said to hinder the pollination of the date palm. When they occur in summer they retard the maturing of the fruit and may even cause it to drop. In Seistan, in the plain of southern Persia, at an altitude of 1,300 feet above the sea level, in the same latitude and altitude as flourishing date oases in the Sahara, date culture is entirely prevented and all other fruit cultures rendered impossible except in the shelter of high walls by the "Badi sado biat," or "120-day wind," a violent, bitterly cold northwest wind which blows from the spring equinox until about July 20.[b] This wind would destroy the flowers of the date palm if they were exposed to it, and as the date palm can not easily be protected by walls, its culture is not attempted in this region, though it is followed in oases lying at higher altitudes far to the north which by their position in the shelter of mountain ranges are protected from such winds. It is possible that in spring cold winds may occur in the Salton Basin, but they are probably less violent than in the Sahara, and are of course not to be compared to the "badi sado biat" of Seistan.

RESISTANCE OF THE DATE PALM TO ALKALI.

The date palm has long been known to withstand large quantities of alkali,[c] and some have even claimed that a certain amount of salt in the soil is beneficial to its growth.[d] As to how much alkali the date palm can resist and still grow and bear fruit in profitable quantities practically nothing definite is on record, notwithstanding the fact that hundreds of thousands of dollars have been invested by the French companies in plantations of date palms in the oases of the Algerian Sahara where alkali abounds. Apparently the date palm is so enormously resistant that it has not been necessary to pay much attention to the amount of alkali in the soil where it is grown. It has been planted on soil of practically all degrees of alkalinity and irrigated with all sorts

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[a] Masselot, Les dattiers des oasis du Djerid. In Bul. Direct. de l'Agriculture et du Commerce, Régence de Tunis, vol. 6 (1901), No. 19, p. 121.

[b] Bellew, H. W. From the Indus to the Tigris, London, 1874, p. 239.

[c] The term alkali is applied rather loosely to the more readily soluble saline matters which accumulate in the soils or in the water of desert regions. In spite of the name such salts are mostly neutral in reaction, consisting chiefly of chlorids, sulphates, and nitrates of the bases sodium, potassium, and magnesium. Only the carbonates of sodium and potassium, constituting the much-dreaded "black alkali," are strongly alkaline in reaction, and because of their caustic nature much more deleterious to most plants than are the neutral salts or "white alkali," which latter are injurious chiefly indirectly by rendering the soil water too concentrated a solution and thereby unfitted to nourish the roots.

[d] Ibn-el-Fasel, an Andalusian Moor, whose book, written in the twelfth century, unfortunately has been lost, is said to have given the exact amounts of salt which should be mixed with the manure for date palms. (See Cusa, Salvatore, in Archivo storico siciliano, I, 1873, p. 356.)

of water, from good drinking water to veritable brine containing 1 per cent of saline matters. It is the custom to provide for drainage, usually by means of open ditches, in the oases having much alkali in the soil or in the water. If the drainage is good, abundant irrigation has the effect of washing the excess of alkali out of the soil. However, even in such situations there has been little study of the best means of preventing the accumulation of alkali or of washing it out of the soil, and many of the planters have no comprehension of its action on the date palm.

INVESTIGATION OF THE ALKALI-RESISTING POWER OF THE DATE PALM IN THE SAHARA.

In view of the entire absence of trustworthy data as to the alkali resistance of the date palm, the writer determined on the occasion of his last visit to the Sahara Desert in 1900 to make a study of the soils in the date plantations in order to determine the amount of alkali these soils contain and what effect it had on the growth and fruiting of the date palm when present in excessive quantities. Samples of soils were secured in five different regions in the Algerian Sahara (see map, Pl. II, p. 76), representing several different methods of culture and drainage and showing all degrees of alkalinity. Through the kindness of Prof. Milton Whitney, Chief of the Bureau (then Division) of Soils of the Department of Agriculture, who also furnished instruments for collecting and studying the soils on the spot, these samples were analyzed by Mr. Atherton Seidell in accordance with the methods usually followed in the Bureau of Soils, namely, by digesting 50 grams of soil in a liter of water for twenty-four hours and then analyzing the supernatant solution. The analyses made in this manner do not represent accurately the conditions existing in the soil water, since the amount of the slightly soluble salts, especially gypsum, reported is far in excess of what could dissolve in the soil moisture, which in the rather sandy loam of most of the Saharan oases would constitute about 8 to 15 per cent of the weight of the soil, whereas in the method followed in making the analyses about 150 to 200 times as much water was used. In this bulletin, therefore, the analyses of Mr. Seidell have been recalculated in order to represent more nearly the conditions existing in the soil. The amount of calcium sulphate that goes into solution in the soil moisture has been estimated at 0.05 per cent in all the analyses, except where large amounts of other sulphates were in solution, when it was estimated at 0.02 per cent. The amount that dissolves undoubtedly varies somewhat, depending on the quantity and nature of the other salts present in solution. However, the amount here estimated is not far from the quantity actually present, and its inclusion in the analyses renders them much more useful than to omit the gypsum

altogether, or to include the very much larger amounts reported in the original analyses.[a]

The solubility of gypsum in the soil moisture is difficult to estimate, especially in the presence of large amounts of other salts in varying proportions. The researches of Doctor Cameron and Mr. Seidell,[b] of the Bureau of Soils, show that in pure water at 25° C. the solubility of calcium sulphate is about 0.21 per cent, or 2.1 grams of calcium sulphate per liter of water, which would equal 0.27 per cent of gypsum. In a 1 per cent solution of common salt 0.44 per cent of gypsum is dissolved, and in a 4.9 per cent salt solution 0.75 per cent of gypsum. In magnesium chloride an even greater solubility was observed and in a 10.5 per cent solution of this salt 11.13 per cent of gypsum dissolves. On the other hand, salts which yield either calcium or sulphuric acid ions on solution decrease the solubility of gypsum. In a 1.54 per cent solution of sodium sulphate only 0.16 per cent of gypsum is dissolved, though in a stronger solution more is taken up until, in a 22.2 per cent solution of sodium sulphate, 0.26 per cent of gypsum is dissolved. Calcium chlorid in solution depresses even more the solvent power of water for gypsum.

Estimating the water content of the Saharan soil, mostly sandy loam, at 10 per cent on the average, and the solubility of calcium sulphate at 0.5 per cent (equal to 0.6 per cent of gypsum) on the average in the salts such as occur in the Fougala and Oued Rirh region of the Sahara, the amount of calcium sulphate to be counted as alkali would be 0.05 per cent of the weight of the soil. When there were large amounts of sodium sulphate present, as at Chegga, the amounts of calcium sulphate would be much less, probably about 0.02 per cent (equal to 0.025 per cent of gypsum) of the weight of the soil.[c]

This method of expressing the amount of alkali is the one most easily applied where the analyses are made by extracting the alkali with an excess of water, but it is very doubtful whether it gives a cor-

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[a] In most alkaline soils the presence of gypsum is advantageous by preventing the formation of the very harmful carbonates of sodium and potassium (see pp. 101 and 119) by neutralizing the poisonous effect of the salts of magnesium (see p. 89). The physical action of alkali in rendering the soil water too concentrated to support the roots of plants is, however, exerted as much by gypsum as by any other salt in solution in equal amounts.

[b] Cameron, Dr. Frank, and Seidell, Atherton. Bul. No. 18, Bureau of Soils, U. S. Department of Agriculture, pp. 39, 40, and 46–57.

[c] Mr. Seidell's original analyses are given in every case as a footnote in order to facilitate any comparisons which students of alkali conditions may desire to make with analyses reported in other ways than has been done by the writer. As a result of this slight emendation the analyses are brought into such shape that the results may be compared, without danger of serious error, with the determinations of alkali made by the electrical method, on which data all the newest and best maps of the alkali lands of the Southwest which have been issued by the Bureau of Soils have been prepared.

rect idea of the alkali condition of the soil in relation to crop production, since the most important factor in reference to plant growth is the degree of concentration of the soil moisture. Inasmuch as the water capacity varies greatly in different types of soils it is easily possible that two soils having the same percentage of alkali by weight may differ very greatly in their ability to support crop plants sensitive to alkali. Thus in a coarse sandy soil having a low water content the concentration of the soil moisture may be three or four times as great as in a heavy clay soil having a correspondingly greater water capacity.

Fortunately it is now possible to determine quickly and accurately the degree of concentration of the soil moisture with the ingenious instrument devised by Professor Whitney and Mr. Briggs, by measuring the electrical conductivity of a column of soil saturated with water.[a] While this method shows approximately the degree of concentration of the soil water to which the roots of plants would be exposed, it gives no indication as to the composition of the alkali, which often varies greatly in soils only a few rods apart. Inasmuch as different sorts of alkali vary greatly in their poisonous action on the roots of plants, the needs of the biologist and agriculturist would be served best by the employment of both methods, the electrical giving the concentration of the soil water; the analytical, its chemical composition. At the same time a physical analysis of the soil showing the water capacity would be useful in forecasting the danger of an increase in alkali content through the evaporation of saline irrigation water or by a rise of alkali from the subsoil.

The soils secured from the Sahara, with the exception of the one above mentioned from Biskra, were all similar in nature, being composed of sandy loam or fine sand. In consequence the results of the analyses reported in this bulletin are fairly comparable one with another and are not likely to lead to an overestimate of the alkali-resisting power of the date palm, since the water capacity of these soils is low, and as a result of this the concentration of the soil water is high in proportion to the percentage of alkali present in the soil. The limits of alkali resistance worked out in this bulletin are then directly applicable to the soils best adapted to date culture, viz, sandy loams, and for all other heavier soils are below rather than above the true limit.[b]

[a] This method depends upon the degree of ionic dissociation, rather than the total content of dissolved substance, and gives the best physical measure of the relative concentration and toxicity of solutions of similar composition.

[b] Very coarse sand would have a lower water capacity than the Saharan soils here studied, but alkali leaches out of coarse sand very easily, so that in such soil a dangerous accumulation of alkali is not common, though if present the limits here determined for the alkali resistance of the date palm would be too high because of the excessive concentration of the soil water in proportion to the percentage of alkali present.

The very unusual ability of the date palm to withstand alkali is of the utmost importance, since it permits it to be grown profitably in soils unfit for any other paying crop and where ordinary vegetation can not grow at all. The date palm is also of great value in aiding in the reclamation of alkaline lands; for once planted to dates and regularly irrigated the soil improves by a washing out of the alkali if the irrigation water is of good quality and if drainage facilities exist. The importance of the alkali-resisting power of this plant is so great that the results of the examination into the alkali conditions in the Algerian Sahara are given in detail, as they constitute the most trustworthy evidence so far in existence as to the amount of alkali the date palm can stand without injury.

ALKALI CONDITIONS IN RELATION TO DATE CULTURE AT BISKRA, ALGERIA.

The first important oasis planted to date palms seen in entering the Sahara by the railway is at El Kantara (see map, Pl. II), where a narrow gorge separates the Algerian high plateau from the Sahara, and in a few moments the train passes from one region to the other. At El Kantara, however, the date palm is chiefly valuable in furnishing a shelter and partial shade to other fruit trees, and it is at Biskra that the date palm is first seen under conditions permitting its best growth. This oasis contained some 95,000 palms in 1882, and now has a total of about 100,000 bearing date palms. The two near-by oases of Filiache and Chetma contain 35,000 more. Biskra is situated in a plain near the west bank of the Biskra River. The irrigation water is furnished by large springs, situated in the bed of the river, which yield about 13,000 liters, or 3,434 gallons, per minute. This water has been analyzed frequently, with fairly concordant results, the content of dissolved salts being given as follows by various chemists: Vatonne, 0.216 per cent; Buvry, 0.2236 per cent; Lahache, 0.226 per cent; Moissonnier, 0.2346 per cent.

The detailed analyses by Moissonnier and Buvry are as follows:

TABLE 11.—*Composition (in percentage, by weight) of spring water used for irrigating the oasis of Biskra, Algeria.*

Authority.	Calcium carbonate.	Magnesium carbonate.	Calcium sulphate.	Magnesium sulphate.	Sodium sulphate.	Magnesium chlorid.	Sodium chlorid.	Silica.	Total.
Moissonnier[1]	0.0278	0.0070	0.0621	0.0357	....	0.0102	0.0894	0.0024	0.2346
Buvry[2]	.0156	....	.0448	....	0.0280	.0474	.0878	....	.2236

[1] Moissonnier, Recueil de mém. de médicine mil., 3 sér., vol. 31, pp. 260–267.
[2] Buvry, Zeitschrft. f. allgem. Erdkunde, N. F., vol. 4, p. 200. Vide Fischer, Die Dattelpalme, p. 41.

In winter, when there is a flow of water in the Biskra River, the water in the irrigating canals may contain as low as 0.075 per cent of dissolved salts, largely gypsum (0.0437 per cent), according to Moissonnier.[a]

The very good quality of the water in winter, together with the shortage of water in summer—there being only 0.1 liter per tree per minute when 0.3 is needed (see p. 45)—favors the practice of winter and spring irrigation commonly followed in this

[a] An analysis of the river water mixed with the spring water after a rainstorm in April, 1880, as reported by Rolland, showed only 0.04 per cent of salts, nearly half calcium carbonate (0.01852 per cent).

PORTION OF THE SAHARA DESERT IN SOUTHERN ALGERIA, SHOWING PRINCIPAL CENTERS OF DATE CULTURE.

oasis, either indirectly by growing crops needing abundant irrigation between the palms, or directly in soaking the ground about the trees. It is doubtless because of the very low alkali content of the irrigation water in winter and the only moderate content in summer that the alkali is not troublesome in this oasis, although surface flooding is never practiced, water being applied in excavations called "dahir," holding a barrel or more (Pl. XVII), which are made about the base of the tree (see p. 47). Biskra has clay soils of great depth[a] (as much as 40 feet) and this doubtless constitutes an additional reason for irrigating by means of dahir, since such soils are difficultly permeable for water and have a great water capacity, so that if irrigation were practiced by flooding the whole surface the water would largely be evaporated or absorbed by the surface layers of the soil, and only a small proportion would ever percolate to the roots of the date palm, especially in summer, when the supply of water is scanty.

Station No. 1, where soil samples were secured, was in a garden belonging to the Victoria Hotel, some 25 feet away from a century-old date palm (see Pl. XIII), and near a vigorous young Deglet Noor palm (see fig. 1, p. 16). Alfalfa and burr clover (*Medicago denticulata*) were growing where the sample was obtained. The subsoil was a stiff clay.

The percentage of the weight of the soil soluble in 20 times its weight of water was 0.42 for the surface foot and 0.40 for the subsoil. The following salts were found by Mr. Seidell:

TABLE 12.—*Amount and nature of salts soluble in excess of water in soil from date garden at Biskra (expressed in percentages of the total weight of the soil).*[1]

Depth.	Calcium bicarbonate.	Magnesium bicarbonate.	Calcium sulphate.	Sodium chlorid.	Potassium chlorid.	Total.
Surface foot	0.19	0.05	0.10	0.04	0.04	0.42
Subsoil (24 to 30 inches)	.15	.06	.11	.04	.04	.40

[1] This table is identical with Mr. Seidell's original analysis.

Disregarding the very slightly soluble calcium carbonate, the following would represent approximately the alkali content of the soil water:

TABLE 13.—*Per cent of alkali in soil of palm garden at Biskra, Algeria.*

Depth.	Calcium sulphate.	Sodium chlorid.	Potassium chlorid.	Magnesium bicarbonate.	Total.
Surface foot	0.5	0.04	0.04	0.05	0.18
Subsoil (12 to 14 inches)	.5	.04	.04	.06	.19

The amount of alkali present in this soil is insignificant and in no way affected the growth of alfalfa. This sample is also interesting as being a heavy clay soil of the sort which largely composes the oasis of Biskra, but which does not occur in the other oases studied. Such soils are not considered as favorable for date culture as loamy or sandy loam soils; nevertheless date palms grow very well at Biskra, although the late sorts do not ripen their fruits properly because the summer and autumn are not hot enough.

Of the area surveyed by Messrs. Holmes and Means, of the Bureau of Soils, in the Salton Basin, California, 23,120 acres, or 30 per cent, is a heavy clay comparable to this sample, and half this area contains less alkali than the Biskra garden, and a quarter more contains only slightly greater quantities (0.4 to 0.6 per cent), where

[a] Such soils are common in the Salton Basin in California. (See Pl. III, pp. 106 and 108.)

the date palm would be able to grow as well as in the Sahara oasis, since the irrigating water here is of better quality than at Biskra.[a]

ALKALI CONDITIONS IN RELATION TO DATE CULTURE AT FOUGALA, ALGERIA.

In proceeding west from Biskra one traverses the so-called Western Zab,[b] which is first seen beyond a low mountain range, the Djebel Mendjenaib, adjoining Biskra on the west. The Western Zab, or more accurately, the Zab Dahri (Map, Pl. II, p. 76, and Pl. XV), is a flat plain, 120 to 172 meters above sea level, which slopes gently to the south or southeast. To the north the plain is limited by the foothills of the Atlas Mountains, which rise rather abruptly. Throughout the Western Zab, at least along the route followed between Biskra and Fougala (see map, Pl. II), there are practically no surface indications of water, the vegetation being very scanty, consisting mostly of the "Zeita" bush (*Limoniastrum guyonianum*), which usually indicates the presence of much gypsum in the soil where it grows (see Yearbook 1900, Pl. LIX, fig. 5). In extremely alkaline spots where chlorids predominate the Zeita disappears, and is replaced by saltbushes (Atriplex), samphires (Salicornia), etc.

There occur throughout the Western Zab occasional large springs which are used to irrigate many oases situated at a somewhat lower level to the southward. Beginning at Farfar there is seen a most characteristic and most curious system of date culture. The young date offshoots are planted at the bottom of pits about six feet square, and from 4 to 8 feet deep (Pl. XV, fig 1). An inspection of a freshly made ditch, or "bir," as it is called by the Arabs, shows that the ditch is just deep enough to penetrate an impervious hardpan, composed of marl and gypsum. Below this stratum water is found and the palms are so planted that their roots can easily penetrate to the water level, and after once getting established they are able to grow without being irrigated from the surface. As the palms grow older the ditches are slowly filled up, the palms in the meantime sprouting forth roots all along the lower part of the trunk. In some cases very old trees are seen to be banked up instead of being planted in ditches (Pl. XIV, fig. 1). Curiously enough the trees planted in such pits are often irrigated, although their roots are in contact with water. As will be shown later on, this is doubtless done in order to aerate the subsoil and to wash out the alkali, which would otherwise be left at the surface by the evaporation of the moisture brought to the surface by capillary attraction. When irrigated, there is of course perfect drainage through the bottom of the "bir" to a practically fixed water level below.

At Fougala a French company purchased an entire oasis containing thousands of old bearing date palms, and has made in addition extensive new plantations. This property comprised in 1900 some 263 hectares and contained about 18,000 bearing date palms and 6,000 young trees not yet in bearing. On this property irrigation has been practiced on an extensive scale, although the older palms were grown by planting in pits as previously described, and were irrigated when young by the Arabic method, namely, by raising water from shallow wells by means of buckets attached to sweeps ("kitara")[c] (Pl. XIV, fig. 2). The wells on this property are from 9 to 12 feet deep and are from 6 to 8 feet square. They yield about 35 gallons per minute, for some three hours, by which time the water is usually exhausted. These sweeps are run at this rate by a single Arab, although on some wells there are double sweeps, and then two Arabs work side by side. The water from such wells is poured into a large receptacle called "jabia," from which it flows into irrigation ditches. In

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[a] Biskra water contains from 0.075 to 0.235 per cent of alkali and is worst in summer. (See p. 76.) Colorado River water used to irrigate the Salton Basin contains from about 0.021 to 0.125 per cent of salts and is best in quality in midsummer, when the flood occurs.

[b] Marked Zibane in the map, Pl. II, p. 76.

[c] See also Yearbook 1900, Pl. LXI, fig. 6.

addition to these native wells the Companie de l'Oued Rirh has put down several artesian wells[a] which are some 80 meters deep and yield from 50 to 75 gallons of flowing water per minute, which is conducted directly into the irrigation ditches. This water is remarkably pure, containing very much less salts in solution than the artesian water of the Oued Rirh country or that of Biskra. A rough test of its electrical conductivity indicated the presence of about 0.085 per cent of dissolved salts.

The effect of irrigation with this water is marvelous. Old date palms which had made a slow and stunted growth and which had fruited but little, at once grew luxuriantly when irrigated and began to bear heavy crops of fruit. Inasmuch as these trees had their roots in constantly moist layers of earth, the effect of irrigation was in all probability due not so much to the increased supply of water as to other actions brought about by irrigation. In the first place, the structure of the soil and the manner in which the date palms are planted in pits which penetrate the hardpan, below which standing water occurs, hinder the aeration of the subsoil and at the same time favor the accumulation at the surface of the alkali dissolved by the capillary currents of water in ascending through the strongly alkaline soil. On the other hand, irrigation with the remarkably pure water furnished by the deep artesian wells would tend to have exactly the opposite effect, namely, the subsoil would be aerated by means of the water which had been flowing in surface ditches, and secondly, the watering of the date palms with an abundant supply of pure water, coupled with a perfect system of drainage by means of the holes through the impervious subsoil[b] over which the trees are planted, would bring about the washing out of the alkali from the soil, especially where the trees were irrigated frequently and with large amounts of water. The hardpan would tend to confine the alkali and prevent its rise between the trees after it was once washed out of the soil.

Although the date palm can grow, as will be shown further on, in soils containing as high as 3 per cent of alkali, even when irrigated with strongly brackish water containing over 0.6 per cent of salts in solution—it being in fact able to endure more alkali than any other plant cultivated in the Sahara Desert—there can nevertheless be no doubt that its growth is retarded and its fruitfulness lessened by the presence of large amounts of alkali in the soil or in the irrigation water. It was noticeable at Fougala that the trees which were grown in the most alkaline parts of the oasis, and especially where surface irrigation with pure water had not been practiced, were stunted and showed a pronounced yellowish color of the leaf and especially of the leafstalk. This was later seen in the oases in the Oued Rirh country, and it would seem to be an indication of an excess of alkali beyond the amount which the trees can endure without noticeable injury.

An effect of pure water similar to that observed at Fougala has been noticed at Koseir, in the Egypto-Arabian desert, on the shores of the Red Sea, where Klunzinger reports[c] that dwarfed date palms 30 to 40 feet high grow on the very alkaline soil and were nourished by very brackish water, but yield crops of small but very sweet dates only in good years after heavy rains. The action of these heavy rains probably would be much like that of the irrigation with the pure artesian water at Fougala.

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[a] The natural springs in the Western Zab, according to Rolland (Hydrologie du Sahara), are supplied from the same source that feeds the artesian wells, viz, the water carried in the cretaceous strata which are upturned in the Aures Mountains limiting the Sahara on the north and which underlie the whole northern belt of the Sahara. The water of these springs soaking into the soil feeds the superficial layer of water which directly underlies the hardpan at Fougala. Very probably this hardpan has been formed by the action of this standing water.

[b] Professor Hilgard has noted the drainage through holes in the hardpan in the San Joaquin Valley in California. Bul. No. 83, California Experiment Station.

[c] Klunzinger, C. B. Die Vegetation der egyptisch-arabischen Wüste bei Koseir, in Zeitschrift d. Gesellschaft f. Erdkunde, Berlin, vol. 13 (1878), pp. 432–462.

It is difficult to say how much of the beneficial effect observed in Fougala from surface irrigation is due to the better aeration of the subsoil thereby brought about. There can, however, be little doubt that the date palm is distinctly favored by a proper aeration of the soil in which it grows, since the palms at Fougala when irrigated from the shallow wells did better than those near by which have their roots in contact with the very same layer of water which fills these wells. Of course the identity of the water supply in the case in question does not exclude the probability of the alkali being washed out from the surface soil by abundant irrigation, even if the water used is rather brackish. Unfortunately no tests were made of the water in these surface wells, but it is undoubtedly much more alkaline than the water of the deep artesian wells. Other observations made at Ourlana in the Oued Rirh region went far to show that proper aeration of the subsoil is even more important than absence of alkali for the proper growth and fruiting of the date palm. For instance, the extremely brackish water which flows from the drainage ditches is nevertheless used in some instances to irrigate palms planted at lower levels and without apparent injury, although such palms do not show a rapid growth (see p. 98).

Station No. 1 at Fougala represents the undisturbed desert conditions (Pl. XV, fig. 1). It was situated where no culture, drainage, or irrigation had been practiced, or at least not in modern times.[a] The samples were taken a short distance to the northeast of the ruins of an old Roman fort. The natural vegetation consisted of a scanty growth of saltbushes, samphires, and other plants able to stand much alkali. A date palm, yellow and evidently not in a thriving condition, was growing near by.

The amount of alkali present in the surface crust and at various depths is shown in the following table:

TABLE 14.—*Per cent of alkali in undisturbed Saharan soil at Station No. 1, Fougala, Algeria.*[1]

Depth.	Calcium sulphate.	Magnesium sulphate.	Sodium sulphate.	Sodium chlorid.	Potassium chlorid.	Magnesium chlorid.	Sodium bicarbonate.	Total.
Surface crust	0.07	0.41	1.44	9.19	0.53	....	0.12	11.76
Surface soil (1 to 12 inches)	.05	.34	.37	3.79	.29	....	.08	4.92
Subsoil (12 to 30 inches)	.05	.23	....	1.32	.12	0.02	.08	1.82
Subsoil (30 to 48 inches—estimated)	(.05)	(.17)	....	(.98)	(.10)	(.02)	(.08)	(1.40)
Soil (1 to 4 feet—estimated)	(0.38)			(1.98)			(.08)	(2.44)

[1] Mr. Seidell's original analyses of the samples from this station are as follows:

Composition.	Crust.		Soil, 0–12 inches.		Subsoil, 12–30 inches.	
	Alkali in soil.	Composition of alkali.	Alkali in soil.	Composition of alkali.	Alkali in soil.	Composition of alkali.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Ca	1.65	9.53	1.39	14.51	1.28	20.89
Mg	.08	.48	.07	.70	.05	.85
Na	4.12	23.81	1.64	17.02	.54	8.83
K	.28	1.60	.15	1.62	.06	1.01
SO_4	5.26	30.42	3.86	40.16	3.26	53.10
Cl	5.82	33.64	2.44	25.37	.88	14.34
HCO_3	.09	.52	.06	.62	.06	.98
Total	17.30	100.00	9.62	100.00	6.13	100.00
$CaSO_4$	5.61	32.38	4.74	49.28	4.36	70.98
$MgSO_4$	.41	2.41	.34	3.49	.23	3.75
KCl	.53	3.08	.29	3.07	.12	1.95
NaCl	9.19	53.06	3.79	39.47	1.32	21.60
Na_2SO_4	1.44	8.35	.37	3.84	....	....
NaHCO	.12	.72	.08	.85	.08	1.33
$MgCl_2$	....	....	....	....	.02	.39
Total	17.30	100.00	9.61	100.00	6.13	100.00

[a] Similar conditions near this station are shown in Yearbook, 1900, Pl. LXI, fig. 4, in the background.

It will be noted that the most readily soluble salts, sodium sulphate and the chlorides, are largely concentrated in the surface soil. This is shown graphically in the accompanying diagram (fig. 9), in which the curves are smoothed so as to show approximately the distribution at various depths of the more important salts composing the alkali at this station.

This distribution of alkali is the common one when there is an appreciable rainfall, as in the northern Sahara (about 9½ inches at Biskra), but is very unlike that of the nearly rainless Salton Basin, where the subsoil often contains more alkali than the surface layers.

This soil was excessively alkaline, the surface foot containing nearly one-twentieth of its weight of alkali, and the whole surface soil to a depth of 4 feet containing nearly 2.5 per cent of alkali. The alkali is characterized by the large proportion of chlorides (amounting to 81 per cent of the total salts), of which almost all is common salt, which alone makes up nearly 4 per cent of the weight of the surface foot, or some 160,000 pounds per acre in the surface foot!

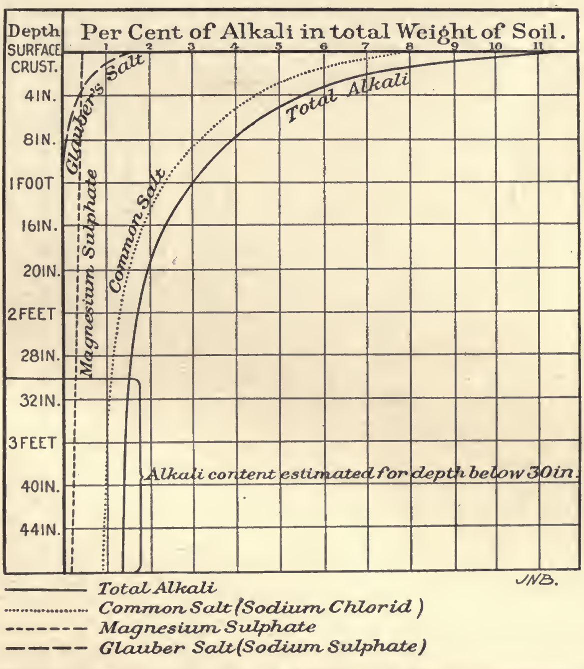

FIG. 9.—Curves showing distribution of alkali to a depth of 4 feet in uncultivated Saharan soil at Station No. 1, Fougala, Algeria.

This soil is very interesting as representing practically the extreme limit of endurance of the date palm for this type of alkali. Unfortunately samples were not obtained down to the hardpan, but if the decrease followed the same ratio as in the Station No. 2, the amount of alkali in the subsoil at 30 to 48 inches would be about 1.42 per cent, and the average for the soil to a depth of 4 feet, 2.55 per cent.

Station No. 2, where the soil was sampled at Fougala, was only a few hundred feet from Station No. 1, in a young date plantation, where irrigation had been practiced for three years. The samples were taken by cutting away a foot or so of the side of the pit, or "bir," in which a date palm had been planted three years before. Fresh earth was reached before the sample was taken. Hardpan was encountered at a depth of 4 feet. The appearance of the locality is shown in the background of Plate XV, figure 2.

The following amounts of alkali were found:

TABLE 15.—*Per cent of alkali in soil of young date plantation, station No. 2, Fougala, Algeria.*[1]

Depth.	Calcium sulphate.	Magnesium sulphate.	Sodium sulphate.	Sodium chlorid.	Potassium chlorid.	Magnesium chlorid.	Sodium bicarbonate.	Total.
Surface, foot	0.05	0.25	0.04	1.38	0.18	....	0.08	1.98
Subsoil (12 to 30 inches)	.05	.15	....	.09	.09	0.05	.08	.51
Subsoil (30 to 48 inches)	.05	.07	....	.06	.07	.04	.09	.38
Hardpan (48 to 54 inches)	.05	.04	....	.04	.06	.04	.08	.31
Soil, 1 to 4 feet		.21			.54		.08	.83

[1] Mr. Seidell's original analyses of the samples from this station are as follows:

	Soil, 0 to 12 inches.		Subsoil, 12 to 30 inches.		Subsoil, 30 to 48 inches.		Compact gypsum subsoil, 48 to 54 inches.	
	Alkali in soil.	Composition of alkali.	Alkali in soil.	Composition of alkali.	Alkali in soil.	Composition of alkali.	Alkali in soil.	Composition of alkali.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Ca	1.30	20.46	1.23	26.50	1.18	27.19	1.08	27.70
Mg	.05	.79	.04	.94	.02	.55	.02	.46
Na	.58	9.14	.06	1.24	.05	1.10	.02	.51
K	.09	1.47	.05	.99	.03	.83	.03	.87
SO_4	3.35	52.70	3.07	66.03	2.90	66.56	2.63	67.28
Cl	.92	14.50	.14	3.01	.10	2.25	.06	1.64
HCO_3	.06	.94	.06	1.29	.06	1.52	.06	1.54
Total	6.35	100.00	4.65	100.00	4.34	100.00	3.90	100.00
$CaSO_4$	4.42	69.56	4.19	89.99	4.02	92.37	3.68	94.08
$MgSO_4$	.25	3.90	.15	3.18	.07	1.70	.04	1.02
KCL	.18	2.83	.09	1.89	.07	1.56	.06	1.64
NaCL	1.38	21.70	.09	2.02	.06	1.43	....	....
Na_2SO_4	.04	.72	....	....	....	....	....	....
$NaHCO_3$	.08	1.29	.08	1.76	.09	2.07	.08	2.09
$MgCl_2$	....	....	.05	1.16	.04	.87	.04	1.17
Total	6.35	100.00	4.65	100.00	4.35	100.00	3.90	100.00

The results of three years' irrigation with pure artesian water is very striking. The surface crust has disappeared entirely and the amount of alkali has greatly decreased at all depths.

Station No. 3 at Fougala was situated in the space between large date palms, which were in a most thriving condition as a result of eleven years' irrigation. Garden vegetables and cereals had been grown on the land for a number of years. The hardpan layer was reached at a depth of only 26 inches.

TABLE 16.—*Per cent of alkali in soil in old date plantation, station No. 3, Fougala, Algeria.*[1]

Depth.	Calcium sulphate.	Magnesium sulphate.	Sodium chlorid.	Potassium chlorid.	Magnesium chlorid.	Sodium bicarbonate.	Magnesium bicarbonate.	Total.
Surface foot	0.05	0.06	0.05	0.02	0.01	0.09	....	0.28
Subsoil, 12–26	.05	.12	....	.06	.05	.10	....	.38
Hardpan, 26–28	.05	.04	....	.03	.04	.03	0.05	.24
Soil 1–4 (estimated)	(.12)		(.08)			(.09)		(.29)

[1] Mr. Seidell's original analyses of the samples from this station are as follows:

	Soil, 0 to 12 inches.		Subsoil, 12 to 26 inches.		Compact gypsum subsoil, 20 to 28 inches.	
	Alkali in soil.	Composition of alkali.	Alkali in soil.	Composition of alkali.	Alkali in soil.	Composition of alkali.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Ca	0.31	24.05	1.10	27.03	1.12	28.03
Mg	.01	1.26	.03	.88	.03	.70
Na	.04	3.30	.03	.69	.01	.25
K	.01	.94	.03	.73	.01	.40
SO_4	.78	61.33	2.74	67.19	2.73	67.94
Cl	.05	3.93	.06	1.57	.04	1.04
HCO_3	.06	5.19	.08	1.91	.06	1.64
Total	1.26	100.00	4.07	100.00	4.00	100.00
$CaSO_4$	1.04	81.76	3.74	91.82	3.81	95.21
$MgSO_4$	.06	4.56	.12	2.98	.04	.95
KCl	.02	1.73	.06	1.37	.03	.75
NaCl	.05	3.77	....	....	....	....
$NaHCO_3$	.09	7.08	.10	2.60	.03	.90
$MgCl_2$	.01	1.10	.05	1.23	.04	.95
$MgHCO_3$	....	....	....	....	.05	1.24
Total	1.27	100.00	4.07	100.00	4.00	10.000

The results of long-continued irrigation with pure water and of good drainage through the holes in the hardpan are clearly shown in the very much lower percentages of alkali than at stations 1 and 2. The most remarkable feature of this soil is the almost complete absence of common salt, so abundant at the other two stations at Fougala, where indeed it constituted the bulk of the alkali. The analyses of the soils from these three stations represent three stages in the reclamation of very alkaline desert land and are very instructive. The conditions somewhat resemble those in the Salton Basin, California, where the irrigation water is also very pure and where likewise the alkali is largely composed of chlorides. In the latter region, however, there is no hardpan through which holes for drainage can be dug and which would serve to keep the alkali down when once it was washed out of the soil. Where good drainage can be provided the soils in the Salton Basin doubtless can be as completely freed from harmful excess of alkali as those of Fougala have been.

Station No. 4 at Fougala was situated in a very alkaline spot—too alkaline to grow any crops—near a date palm which was yellow and stunted, but which had nevertheless managed to live twenty years or more. Only the surface crust was secured; it showed the following percentages of alkali salts soluble in an excess (20 times the weight of the soil sample) of water. The surface crust from station No. 1 is also given, analyzed in the same way.

TABLE 17.—*Per cent of alkali soluble in excess of water in surface crusts from Fougala, Algeria.*

Station.	Calcium sulphate.	Magnesium sulphate.	Sodium sulphate.	Sodium chlorid.	Potassium chlorid.	Sodium bicarbonate.	Total.
Surface crust, station No. 4[1]	3.81	0.84	5.52	4.32	0.40	0.15	15.04
Surface crust, station No. 1	5.61	.41	1.44	9.19	.53	.12	17.30

[1] Mr. Seidell's original analysis of this surface crust is as follows:

	Surface soil.			Surface soil.	
	Alkali in soil.	Composition of alkali.		Alkali in soil.	Composition of alkali.
	Per cent.	*Per cent.*		*Per cent.*	*Per cent.*
Ca	1.12	7.44	$CaSO_4$	3.81	25.26
Mg	.17	1.13	$MgSO_4$	.84	5.60
Na	3.53	23.51	KCl	.40	2.69
K	.21	1.41	NaCl	4.32	28.77
SO	7.08	47.10	Na_2SO_4	5.52	36.71
Cl	2.81	18.71	$NaHCO_3$	.15	.97
HCO_3	.12	.70	Total	15.04	100.00
Total	15.04	100.00			

The crust from Station No. 4 shows less than half as much common salt (sodium chlorid), but four times as much Glauber's salt (sodium sulphate) as that from station No. 1.

ALKALI CONDITIONS IN RELATION TO DATE CULTURE AT CHEGGA, ALGERIA.

In traveling southward from Biskra one follows near the course of the Biskra River, and passes occasional areas covered with bushes and small trees, which doubtless get scanty supplies of water by seepage from the subterranean flow in the river. After crossing the Oued Djedi (see map, Pl. II, p. 76), which is the principal artery of surface drainage of the Algerian Sahara, but which is usually entirely dry, the Small Desert of Morran is entered, a region almost entirely devoid of vegetation. At about 30 miles south of Biskra the "bordj"[a] of Chegga (see map, Pl. II, p. 76) is reached. Chegga is about 22 meters (72 feet) above sea level, and is only about 8 miles from the Chott Melrirh, a salt lagoon nearly dry, which is here some 90 feet below sea level. Samples were secured of the water from a flowing artesian well which irrigates the little group of palms near the bordj, and which in spite of its bad quality is used for drinking and for cooking purposes.

About a mile to the eastward and at a somewhat lower level is a date plantation of some size, the property of a French company. Here samples were secured of the artesian water used to irrigate this plantation. Analyses are given herewith of the water of the two artesian wells at Chegga, made by Mr. Seidell, and also the analysis by Carnot[b] (of the École des Mines, Paris) of the water from the Bir Djefaïr well, some 6 miles north of Chegga.

[a] A bordj is a fortified shelter for travelers, such as is common in Algeria.

[b] Rolland, Hydrologie du Sahara, p. 294.

TABLE 18.—*Composition (in percentage by weight) of artesian water at Chegga and of the well at Bir Djefaïr, Algeria.*

Locality.	Calcium carbonate.	Magnesium carbonate.	Iron carbonate.	Calcium sulphate.	Magnesium sulphate.	Sodium sulphate.	Sodium chlorid.
Chegga, bordj [1]	....	....	....	0.1790	0.0629	0.2067	0.0803
Chegga, date plantation [1]	....	....	....	.2062	.0966	.1215	.1955
Bir Djefaïr [2]	0.01536	0.00187	0.00102	.17784	.08632	.06214	.05364

Locality.	Potassium chlorid.	Sodium carbonate.	Sodium bicarbonate.	Silica.	Nitrates and soluble organic matter.	Organic and mineral matter in suspension.	Total.
Chegga, Bordj [1]	0.0133	0.0030	0.0033	....	....	....	0.5485
Chegga, date plantation [1]	.0127	.0030	.0046	....	....	....	.6401
Bir Djefaïr [2]	.00632	....	....	0.00480	0.00030	0.00280	.41291

[1] Mr. Seidell's original analyses of artesian water of Chegga are as follows:

	Well at date plantation.		Well at Bordj (drinking water).	
	Alkali per 100 cc.	Composition of alkali.	Alkali per 100 cc.	Composition of alkali.
	Gram.	*Per cent.*	*Gram.*	*Per cent.*
Ca	0.0607	9.48	0.0527	9.61
Mg	.0195	3.05	.0127	2.32
Na	.1190	18.59	.1008	18.37
K	.0067	1.05	.0070	1.28
SO_4	.3047	47.60	.3162	57.65
CO_3	.0017	.27	.0017	.31
HCO_3	.0033	.51	.0024	.44
Cl	.1245	19.45	.0550	10.02
Total	.6401	100.00	.5485	100.00
$CaSO_4$	.2062	32.22	.1790	32.63
$MgSO_4$	.0966	15.09	.0629	11.47
KCl	.0127	1.98	.0133	2.42
Na_2SO_4	.1215	18.98	.2067	37.69
NaCl	.1955	30.54	.0803	14.64
Na_2CO_3	.0030	.47	.0030	.55
$NaHCO_3$	.0046	.72	.0033	.60
Total	.6401	100.00	.5485	100.00

[2] Rolland, Hydrologie du Sahara.

The preponderance of sulphates is marked in the water of the well used to irrigate the date plantation. They constitute 66.28 per cent of the total soluble salts, whereas the chlorids make up only 32.529 per cent.[a]

The contrast with Fougala is most striking. There the artesian water was very pure, containing only about 0.085 per cent of dissolved salts, whereas at Chegga the water contained 0.6401 per cent, or nearly eight times as much alkali. This water

[a] The analyses made by Lahache (Archives de médicine milit., vol. 14 (1889), p. 50) have shown the existence of soluble nitrates in the artesian water of all regions of the Algerian Sahara. At Chegga 22.5 grams per cubic meter were found, or 0.00023 per cent, corresponding closely to the 0.00030 per cent of nitrates and dissolved organic matter reported by Carnot in the analysis of the water of the well at Bir Djefaïr. No nitrates were found by Mr. Seidell, though tests were made. Possibly the small amounts present had been consumed by micro-organisms before the water was analyzed. The nitrates present in the artesian water are considered by Marcassin (Annal. Inst. Nat. Agron., 1895) to be of considerable importance in supporting the date palm and other vegetation grown by irrigation in the Algerian Sahara.

would be counted too alkaline to use for irrigation[a] anywhere outside of the Sahara, though at Chegga it is the only water used to irrigate a flourishing date orchard planted on soil originally very alkaline, but which has been improved, even while being irrigated with such water, by means of drainage ditches into which the excess of alkali has been washed. Figure 1 on Plate XVI shows the appearance of these palms growing where alkali can be seen at the side of the irrigation ditches. Figure 2 on the same plate shows a reclaimed area where Saharan alfalfa was growing.

Station No. 1 at Chegga was in the date plantation in a very alkaline spot, close to an offshoot that had failed to grow, probably because of the excess of alkali in the soil. The subsoil was taken from the side of the drainage ditch, some 18 feet away, and may not represent the true state of the subsoil where the surface soil and crust were taken.

The crust shows the following amounts of alkali soluble in an excess of water (20 times weight of soil sample):

TABLE 19.—*Per cent of alkali soluble in excess of water in surface crust from Station No. 1, Chegga, Algeria.*[1]

Locality.	Calcium sulphate.	Magnesium sulphate.	Sodium sulphate.	Sodium chlorid.	Potassium chlorid.	Sodium bicarbonate.	Sodium carbonate.	Total.
Chegga, Station 1, surface crust......	3.76	1.68	55.44	2.87	0.15	0.16	0.06	64.12

The soil shows the following amounts of alkali:

TABLE 20.—*Per cent of alkali in soil of date plantation, Station 1, Chegga, Algeria.*[1]

Depth.	Calcium sulphate.	Magnesium sulphate.	Sodium sulphate.	Sodium chlorid.	Potassium chlorid.	Sodium bicarbonate.	Total.
Surface foot	0.02	0.20	4.89	0.53	0.10	0.08	5.82
Subsoil at 3 feet	.02	.25	1.50	.80	.08	.06	2.71
Soil 1 to 4 feet (estimated).....		(2.61)			(.82)	(.07)	(3.50)

[1] Mr. Seidell's original analyses of the samples from this station are as follows:

	Crust.		Soil, 0–12 inches.		Subsoil, 36 inches.	
	Alkali in soil.	Composition of alkali.	Alkali in soil.	Composition of alkali.	Alkali in soil.	Composition of alkali.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Ca	1.11	1.72	0.97	10.68	0.96	16.12
Mg	.34	.53	.04	.44	.05	.84
Na	19.18	29.90	1.81	19.94	.82	13.77
K	.08	.12	.06	.71	.04	.74
SO_4	41.46	64.68	5.79	63.63	3.51	59.03
Cl	1.81	2.82	.36	3.94	.52	8.82
HCO_3	.12	.18	.06	.66	.04	.68
CO_3	.03	.05	....	....	....	....
Total........	64.13	100.00	9.10	100.00	5.94	100.00
$CaSO_4$	3.76	5.85	3.30	36.30	3.25	54.75
$MgSO_4$	1.68	2.62	.20	2.18	.25	4.18
KCl	.15	.23	.10	1.12	.08	1.42
NaCl	2.87	4.47	.53	5.80	.80	13.47
Na_2SO_4	55.44	86.49	4.89	53.70	1.50	25.24
$NaHCO_3$	.16	.25	.08	.90	.06	.94
Na_2CO_3	.06	.09	....	....	....	....
Total........	64.13	100.00	9.09	100.00	5.94	100.00

[a] The Chegga water contains over 374 grains of alkali per gallon; whereas 40 grains is usually given as the limit for drinking water, and anything above this is considered doubtful for irrigating purposes, unless the salt in solution is gypsum. Even excluding gypsum, the Chegga water still contains 250 grains to the gallon, whereas the water of Lake Elsinore, which so disastrously affected the orange groves on which it was used near Riverside, Cal., contained only 84 to 116 grains per gallon. (See Report, California Agricultural Experiment Station, 1897–98, pp. 99–113 and 126–130.)

The amount of alkali is enormous, the largest found in a date plantation in the Sahara, and is probably more than young offshoots just rooting can stand, as is evidenced by the death of one planted not long before the sample was taken. Older palms can doubtless endure this amount of alkali, for several were growing near by in soil apparently identical with the sample analyzed. It should be noted that the bulk of the alkali (some 70 per cent of all the alkali present and 2.35 per cent of the total weight of the soil), is sodium sulphate (Glauber's salt), and only 23 per cent of the alkali, or 0.82 per cent of the total weight of the soil, is composed of chlorids, whereas at Fougala, Station 1, where the alkali was also almost strong enough to prevent the growth of the date palm, the total alkali content of the soil was much less, being some 2.46 per cent instead of 3.53 per cent, but consisted of 1.98 per cent of chlorids, more than twice as much as at Chegga. The chlorids are, however, without doubt more injurious than sodium sulphate, and both of these stations are to be considered as representing very nearly the limit of endurance of the date palm—Fougala for chlorids; Chegga for sulphates.

The surface accumulation of sodium sulphate, as suggested by Mr. Seidell, may well have some connection with the composition of the very alkaline waters used for irrigation in which the sulphates predominate and in which sodium sulphate is present to the extent of 121.5 parts per 100,000, constituting 18.98 per cent of the dissolved salts (see p. 95).

Station No. 2, at Chegga (Pl. XVI, fig. 2), is very unlike the first, as it represents reclaimed land where Saharan alfalfa[a] was growing. It is to be noted that deep drainage ditches ran through the orchard at 50 to 60 feet intervals and provided escape for the superabundant alkali, and that this sample was secured near one of these ditches as may be seen in Plate XVI, figure 2. The analysis is given herewith.

TABLE 21.—*Per cent of alkali in washed-out surface soil of date plantation, station No. 2, Chegga, Algeria.*[1]

Depth.	Calcium sulphate.	Magnesium sulphate.	Sodium sulphate.	Sodium chlorid.	Potassium chlorid.	Sodium bicarbonate.	Total.
Surface foot	0.02	0.17	0.04	0.05	0.05	0.06	0.39

[1] Mr. Seidell's original analysis of the samples from this station is as follows:

	Alkali in soil.	Composition of alkali.		Alkali in soil.	Composition of alkali.
	Per cent.	*Per cent.*		*Per cent.*	*Per cent.*
Ca	1.04	26.57	$CaSO_4$	3.54	90.29
Mg	.03	.87	$MgSO_4$	.17	4.29
Na	.05	1.28	KCl	.05	1.38
K	.03	.72	NaCl	.05	1.33
SO_4	2.65	67.81	Na_2SO_4	.04	1.02
Cl	.06	1.53	$NaHCO_3$	.06	1.69
HCO_3	.05	1.22			
Total	3.91	100.00	Total	3.91	100.00

This soil shows a very low per cent of alkali, considering that the date plantation is on a very alkaline area and that the water used for irrigating is very brackish. This is almost the same amount of alkali as was found in the valley of the Colorado River near Yuma, where alfalfa grew in soil containing 0.498 per cent of alkali in the 4 upper feet (Loughridge, Bull. 133, California Agricultural Experiment Station, p. 27). However, at Yuma the irrigation water was of good quality, containing less than 0.1 per cent of dissolved salts, whereas at Chegga the water was very bad, containing over 0.64 per cent of alkali.

[a] See footnote *a*, p. 23.

Station No. 3, at Chegga, represents a subsoil thrown up in digging a drainage ditch and was so charged with alkali as to have become nearly solid. The soil came from a depth of 4 to 6 feet, and contains the following amounts of alkali:

TABLE 22.—*Per cent of alkali in subsoil of date plantation, station No. 3, Chegga, Algeria.*[1]

Depth.	Calcium sulphate.	Magnesium sulphate.	Sodium sulphate.	Sodium chlorid.	Potassium chlorid.	Sodium bicarbonate.	Total.
Subsoil 4 to 6 feet	0.02	0.33	0.22	1.16	0.06	0.07	1.86

[1] Mr. Seidell's original analysis of the sample from this station is as follows:

	Alkali in soil.	Composition of alkali.		Alkali in soil.	Composition of alkali.
	Per cent.	*Per cent.*		*Per cent.*	*Per cent.*
Ca	1.11	19.77	$CaSO_4$	3.76	67.17
Mg	.06	1.18	$MgSO_4$	.33	5.82
Na	.55	9.74	KCl	.06	1.14
K	.03	.61	NaCl	1.16	20.66
SO_4	3.07	54.71	Na_2SO_4	.22	3.96
Cl	.73	13.06	$NaHCO_3$	.07	1.25
HCO_3	.05	.93			
Total	5.60	100.00	Total	5.60	100.00

Though less alkaline than the subsoil of sample No. 1, which contained 2.765 per cent, this still shows a very high salt content.

When date palms were first planted on this property, many of the offshoots were lost through excessive alkalinity. The digging of drainage ditches has rendered it possible to wash out much of the alkali, even with the very bad water used for irrigation, as is evidenced by the fact that alfalfa can now grow on some of the land.

ALKALI CONDITIONS IN RELATION TO DATE CULTURE AT M'RAÏER, ALGERIA.

Going southward from Chegga, the Little Desert of Moran is traversed until a somewhat abrupt descent is reached, which is marked by a series of low cliffs called Kef el Dohr. At the base of this declivity there extends an almost unbroken plain, which slopes gently to the eastward to the shores of the salt lagoon, Chott Melrirh, or rather a branch of it called Chott Merouan (see map, Pl. II, p. 76). This salt lagoon is often dry, but always contains mud covered with a white crust of salt two-fifths of an inch or more thick. In proceeding southward, the road skirts the edge of the lagoon, and during the heat of the day the most deceptive mirages are seen in looking across the Chott (Pl. XVIII, fig. 2).

This region is remarkably like the Salton Basin in many ways, and Chott Melrirh, like Salton Lake, is below sea level,[a] the lowest part or the western border of Chott Melrirh being some 100 feet (31 meters) below sea level. The plain to the west is flat and extremely arid. Occasional small sand dunes occur, which are like those in the Salton Basin.

The oasis of Ourir, seen in passing, is one of the largest created by the French settlers, containing some 40,000 date palms. It is 42 feet (13 meters) below the sea level.

A stop was made at M'raïer, an oasis of considerable size (some 60,000 date palms) owned by Arabs. It is from 10 to 12 feet below sea level. In the village of M'raïer is a very saline area, where the scanty vegetation is composed of stunted saltbushes, samphires, etc. The water level was only a few inches below the surface. A stunted date palm grew some 15 feet away from the spot where the soil sample was obtained, but

[a] The lowest part of Salton Lake is some 270 feet below sea level.

at the side of a drainage ditch. The surface crust obtained here shows the following composition, as analyzed by Mr. Seidell, by extracting with an excess of water 20 times the weight of the sample:

TABLE 23.—*Per cent of alkali soluble in excess of water, in surface crust from Mraïer, Algeria.*[1]

Depth.	Calcium sulphate.	Magnesium sulphate.	Sodium sulphate.	Sodium chlorid.	Potassium chlorid.	Sodium bicarbonate.	Total.
Surface crust	4.66	12.31	8.92	29.18	0.98	0.27	56.32

[1] Mr. Seidell's original analysis of the sample from this station is as follows:

	Alkali in sample.	Composition of sample.		Alkali in sample.	Composition of sample.
	Per cent.	*Per cent.*		*Per cent.*	*Per cent.*
Ca	1.37	2.43	$CaSO_4$	4.66	8.27
Mg	2.48	4.41	$MgSO_4$	12.31	21.86
Na	14.46	25.68	KCl	.98	1.74
K	.52	.92	NaCl	29.18	51.82
SO_4	19.14	33.98	$NaHCO_3$	.27	.48
Cl	18.15	32.23	Na_2SO_4	8.92	15.83
HCO_3	.20	.35			
Total	56.32	100.00	Total	56.32	100.00

This crust is remarkable among those collected in the Sahara for its low content of calcium sulphate (8.277 per cent of total alkali) and the high content of magnesium sulphate (21.86 per cent of total alkali). The extreme sterility of the sink where the sample was secured may be due in part to the excess of magnesium over lime, which has been shown by Loew[a] to be very injurious to most plants. This was the only sample obtained in the Sahara, where magnesium sulphate was in excess of gypsum. Common salt makes up one-half (52 per cent) of the crust.

ALKALI CONDITIONS IN RELATION TO DATE CULTURE AT OURLANA, ALGERIA.

Going southward from M'raïer one soon enters the Oued Rirh region proper. The Oued Rirh or Rirh River is a chain of chotts (salt lagoons or dry salt beds) occupying a partially filled up, dry valley, which runs from Tougourt almost due north to the Chott Melrirh, with a gradual fall to the north, amounting to some 270 feet in the 70 miles from Bledet Amar[b] to Chott Merouan (see map, Pl. II, p. 76). The Oued Rirh has a very shallow valley, bordered on the west by a nearly flat plain of sandy loam soil (largely planted to date palms), which rises gradually toward the barren hills, which are reached at a distance of from one-half to 10 miles from the valley. To the east of the chain of Chotts this country is sandy, and dunes occupy most of the surface. Small dunes sometimes occur on the west side of the valley.

This valley is some 200 feet above sea level at Tougourt and is slightly below sea level where it enters the Chott Merouan. It is abundantly supplied with flowing artesian wells and is one of the most celebrated date regions in the world. The famous Deglet Noor date, reported in Tunis to have originated in the oasis of Bledet Amar near Temacin at the southern end of the Oued Rirh, is largely grown here and constitutes almost the sole export. In all parts of the Oued Rirh date culture is the chief industry, and in many oases the date is the only plant grown, as the very

[a] Loew, O. Relation of Lime and Magnesia to Plant Growth, Bul. No. 1, Bureau of Plant Industry, U. S. Dept. of Agriculture, and also Kearney and Cameron, Report 71, U. S. Dept. of Agriculture.

[b] Marked Bled et Ahmar in the map, Plate II, page 76.

alkaline soil and the high salt content of the irrigation water preclude other profitable cultures.

The artesian water at Ourlana, as elsewhere in the Oued Rirh, is confined below a compact stratum of pudding stone which lies some 175 to 250 feet below the surface. Below this pudding stone is a layer of loose quartz sand, more or less mixed with pebbles, which contains an abundant supply of water under sufficient pressure to give a ready flow, frequently to the tops of the lower hillocks in the plain.

The French engineers Jus and Rolland, who have studied exhaustively the question of the origin of the water supply of the Oued Rirh, agree in believing that the original source is in the Atlas Mountains to the north, where the heavy rainfall and snowfall (some 5¼ feet annually) is absorbed by the upturned cretaceous strata and conducted in these strata to the south, where it first reappears in the great springs of the Zab region along the northern border of the Sahara. The water of these springs and of many others which are believed to exist, though the water never reaches the surface, soaks into the pervious strata of the Saharan formation and flows southward toward the Oued Rirh country,[a] becoming imprisoned beneath an impervious pudding-stone layer, except where natural openings exist and allow the water to reach the surface[b] or where artesian wells have been put down.

On the 1st of October, 1885, Oued Rirh contained 114 flowing wells put down by the French and tubed with iron, 492 flowing wells constructed by the natives, and 22 natural springs, which were used for irrigating. The total supply of water furnished by these wells and springs was 253,698 liters per minute, or 4 cubic meters (over 1,050 gallons) per second, having an average temperature of 25.1° C. The largest flowing well is No. 4, at Sidi Amran, which was put down in 1884. It flows 6,000 liters per minute.

The beneficial effect of French occupation has been very marked in the Oued Rirh, where in 1856 there were 33 oases, all in a state of decay. They were nourished by 58,000 liters of water per minute and contained only 136,000 date palms, for the most part old and yielding but little fruit. Thirty years later, thanks to the artesian wells put down by the French, the total yield of water had been raised to more than 253,000 liters per minute; all the old oases had been put in a flourishing condition and new ones had been created, so that in 1885 there were 43 oases containing 509,375 date palms in full bearing, and about 138,000 young palms from 1 to 7 years old. The native population had more than doubled during this time and the value of the oases had increased more than fivefold.

The oasis of Ourlana, of which a special study was made, is located nearly 100 miles south of Biskra, at an altitude of 113 feet above sea level, and is in the most fertile part of the Oued Rirh. Within a radius of 10 miles of Ourlana there are no fewer than 15 oases irrigated from 32 artesian wells (30 of which are modern tubed wells of French construction) and from 16 springs—"behour." These 15 oases contained in 1882 over 182,000 date palms, and nearly half of these oases have been much enlarged since then, so that they now, doubtless, contain over 200,000 date palms.

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[a] The water of these springs of the western Zab contains on the average 0.203 per cent of dissolved salts. Those springs which reach the surface indirectly after filtering a distance through the superficial strata yield water showing a larger per cent of alkali—about 0.268 per cent on the average—and by the time the water has soaked its way through the Saharan strata and flowed to the Oued Rirh country, the alkali content has risen to an average of 0.487 per cent.

[b] Forming the springs and small lagoons called "behour" and "chria" by the Arabs.

The well—Puits Desveaux—from which the plantation was irrigated, yields an abundant supply of very alkaline water. Mr. Seidell's analysis is as follows:

TABLE 24.—*Composition of artesian water (Puits Desveaux) used to irrigate date plantation at Ourlana, Algeria.*[1]

	Calcium sulphate.	Magnesium sulphate.	Magnesium chlorid.	Sodium chlorid.	Potassium chlorid.	Sodium carbonate.	Sodium bicarbonate.	Total.
Composition in grams per 100 cc. (percentage by weight)	0.2327	0.0645	0.0690	0.2478	0.0143	0.0030	0.0040	0.6353
Percentage of total salt content	36.70	10.13	10.85	38.98	2.25	.47	.64	100.00

[1] Mr. Seidell's original analysis of the artesian water of Ourlana is as follows:

	Alkali per 100 cc.	Composition of alkali.		Alkali per 100 cc.	Composition of alkali.
	Gram.	*Per cent.*		*Gram.*	*Per cent.*
Ca	0.0685	10.78	$CaSO_4$	0.2327	36.70
Mg	.0305	4.80	$MgSO_4$	.0645	10.13
Na	.1001	15.75	$MgCl_2$	.0690	10.85
K	.0075	1.18	KCl	.0143	2.25
SO_4	.2155	33.91	NaCl	.2478	38.98
CO_3	.0017	.27	Na_2CO_3	.0030	.47
HCO_3	.0030	.47	$NaHCO_3$	.0040	.64
Cl	.2085	32.83			
Total	.6353	100.00	Total	.6353	100.00

In contrast to the water of Chegga (see p. 85), having almost the same amount of dissolved salts, in which the sulphates predominated, the chlorides are here in excess, constituting 52 per cent of the total dissolved salts, while the sulphates make up 46.83 per cent. The average of 26 analyses of the water from flowing artesian wells in the Oued Rirh is given by Rolland[a] as follows:

TABLE 25.—*Average composition (in percentage by weight) of 26 samples of artesian water from the Oued Rirh, Algeria.*

Sulphates	0.25436
Chlorids	.21279
Carbonates	.01257
Nitrates and dissolved organic matter	.00411
Silicates and suspended matter	.00310
Total	.48693

It will be noticed that the sulphates preponderate over the chlorids in this table, though not so much as in the Chegga water.

Station No. 1 at Ourlana was near the bordj and not far from the well. Young and old date palms were growing near by in good condition. There was an open drainage ditch near by, but this did not prevent the formation of a surface crust of alkali. At 36 inches below the surface water was found, and below that level the sand was very wet, resembling quicksand.

[a] Rolland, Hydrologie du Sahara, p. 260.

The surface crust showed the following composition:

TABLE 26.—*Per cent of alkali soluble in excess of water in surface crust, from Station No. 1, Ourlana, Algeria.*[1]

Calcium sulphate	3.21
Magnesium sulphate	2.67
Magnesium chlorid	.71
Sodium chlorid	7.52
Potassium chlorid	.29
Sodium bicarbonate	.12
Total	14.52

The soil to a depth of 4 feet showed the following amounts of alkali:

TABLE 27.—*Per cent of alkali in soil of date orchard, Station No. 1, at Ourlana, Algeria.*[1]

Depth.	Calcium sulphate.	Magnesium sulphate.	Sodium chlorid.	Potassium chlorid.	Magnesium bicarbonate.	Sodium bicarbonate.	Total.
Surface foot	0.05	0.16	0.23	0.03	0.03	0.03	0.53
Subsoil, 12 to 24 inches	.05	.11	.16	.01	.04		.37
Subsoil, 24 to 36 inches	.05	.09	.12	.03	.03		.32
Subsoil, 36 to 48 inches	.05	.10	.13	.02	.02	.03	.35
Soil, 1 to 4 feet	.165		.18		.045		.39

[1] Mr. Seidell's original analyses of the samples from this station are as follows:

	Crust.		Soil (0–12 inches).		Subsoil (12–24 inches).		Subsoil (24–36 inches).		Subsoil (36–48 inches).	
	Alkali in soil.	Composition of alkali.	Alkali in soil.	Composition of alkali.	Alkali in soil.	Composition of alkali.	Alkali in soil.	Composition of alkali.	Alkali in soil.	Composition of alkali.
	Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
Ca	0.95	6.51	0.75	24.80	0.30	22.43	0.24	22.16	0.26	21.77
Mg	.72	4.96	.04	1.18	.03	2.12	.02	2.20	.02	2.04
Na	2.99	20.62	.10	3.22	.06	4.54	.05	4.21	.06	5.10
K	.15	1.04	.01	.53	.01	.45	.01	1.28	.01	1.02
SO_4	4.40	30.30	1.95	63.83	.80	60.32	.65	59.71	.69	58.84
Cl	5.23	35.99	.15	5.06	.10	7.87	.08	7.69	.09	7.83
HCO_3	.08	.58	.04	1.38	.03	2.27	.03	2.75	.04	3.40
Total	14.52	100.00	3.04	100.00	1.32	100.00	1.09	100.00	1.17	100.00
$CaSO_4$	3.21	22.13	2.56	84.28	1.00	75.95	.82	75.27	.87	73.98
$MgSO_4$	2.67	18.39	.16	5.40	.11	8.32	.09	8.24	.10	8.33
KCl	.29	1.99	.03	.99	.01	.90	.03	2.38	.02	1.87
NaCl	7.52	51.78	.23	7.57	.16	12.11	.12	10.81	.13	11.40
$NaHCO_3$	.12	.80	.03	.99					.03	2.38
$MgCl_2$	.71	4.91								
$MgHCO_3$			.03	.77	.04	2.72	.03	3.30	.02	2.04
Total	14.52	100.00	3.04	100.00	1.32	100.00	1.09	100.00	1.17	100.00

The fourth foot from the surface, where the subsoil was full of water, shows a larger amount of alkali than does the third foot. This amount of alkali was evidently without effect on the date palm.

Station No. 2 at Ourlana (Pl. XVII, fig. 1) was of much interest, because located between old and flourishing date palms which had been planted ten years or more. Notwithstanding the existence of a drainage ditch only a few feet away and of the fact that the irrigation water had been applied to the whole surface of the soil by flooding, the surface still showed a considerable crust of alkali. Water was encountered at a depth of 30 inches, which was below the level of the shallow drainage ditch.

The surface crust showed the following composition:

TABLE 28.—*Per cent of alkali soluble in excess of water in surface crust, Station No. 2, Ourlana, Algeria.*[1]

Calcium sulphate	4.88
Magnesium sulphate	2.57
Magnesium chlorid	.60
Sodium chlorid	10.15
Potassium chlorid	.11
Sodium bicarbonate	.12
Total	18.43

The following table shows the amount of alkali in the soil:

TABLE 29.—*Per cent of alkali in soil of date plantation, Station No. 2, Ourlana, Algeria.*[1]

Depth.	Calcium sulphate.	Magnesium sulphate.	Magnesium chlorid.	Sodium chlorid.	Potassium chlorid.	Sodium bicarbonate.	Total.
Surface, foot	0.05	0.15	0.27	0.90	0.05	0.07	1.49
Subsoil, 30 to 34 inches	.05	.15	....	.17	.03	.08	.48
Soil, 1 to 4 feet (estimated).	(.20)		(.445)			(.077)	(.72)

[1] Mr. Seidell's original analyses of the samples from this station are as follows:

	Crust.		Soil (0–12 inches).		Subsoil (30–34 inches).	
	Alkali in soil.	Composition of alkali.	Alkali in soil.	Composition of alkali.	Alkali in soil.	Composition of alkali.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Ca	1.44	7.79	1.24	21.91	1.02	26.15
Mg	.67	3.65	.10	1.77	.03	.76
Na	4.03	21.88	.37	6.61	.09	2.30
K	.06	.31	.03	.50	.02	.46
SO_4	5.49	29.80	3.09	54.63	2.57	65.77
Cl	6.65	36.08	.77	13.64	.12	3.02
HCO_3	.09	.49	.05	.95	.06	1.54
Total	18.43	100.00	5.65	100.00	3.91	100.00
$CaSO_4$	4.88	26.47	4.21	74.41	3.48	88.89
$MgSO_4$	2.57	13.94	.15	2.65	.15	3.79
$MgCl_2$	.60	3.27	.27	4.84	....	....
KCl	.11	.60	.05	.92	.03	.82
NaCl	10.15	55.05	.90	15.87	.17	4.40
$NaHCO_3$	.12	.67	.07	1.31	08	2.10
Total	18.43	100.00	5.65	100.00	3.91	100.00

The date palms were growing luxuriantly and fruiting abundantly here, entirely unaffected by the alkali, though they must withstand nearly one-half per cent of chlorids. It is interesting to note that over 60 per cent of the land surveyed by the Bureau of Soils in the Salton Basin has less alkali than was contained in this soil.

Station No. 3 at Ourlana was situated about half a mile from the bordj, in a low and badly drained part of the orchard, where the palms did not look so vigorous and healthy as they did elsewhere. Below 26 inches' depth the sand was full of water and perfectly fluid, like quicksand.

The surface crust showed the following composition:

TABLE 30.—*Per cent of alkali soluble in excess of water in surface crust, Station No. 3, Ourlana, Algeria.*[1]

Calcium sulphate	3.23
Magnesium sulphate	.03
Magnesium chlorid	.49
Sodium chlorid	1.20
Potassium chlorid	.07
Sodium bicarbonate	.12
Total	5.14

The following table shows the amount of alkali in the soil:

TABLE 31.—*Per cent of alkali in soil, Station No. 3, Ourlana, Algeria.*[1]

Depth.	Calcium sulphate.	Magnesium sulphate.	Magnesium chlorid.	Sodium chlorid.	Potassium chlorid.	Sodium bicarbonate.	Total.
Surface, foot	0.05	....	0.08	0.04	0.02	0.08	0.27
Subsoil, 12 to 26 inches	.05	....	.09	.04	.04	.07	.29
Subsoil, 26 to 30 inches	.05	0.04	.07	.11	.04	.07	.38
Soil, 1 to 4 foot (estimated)	(.07)		(.19)			.07	.33

[1] Mr. Seidell's original analyses of the samples from this station are as follows:

	Crust.		Soil (0 to 12 inches).		Subsoil (12 to 36 inches).		Quicksand (26 to 30 inches).	
	Alkali in soil.	Composition of alkali.	Alkali in soil.	Composition of alkali.	Alkali in soil.	Composition of alkali.	Alkali in soil.	Composition of alkali.
	Per cent.		*Per cent.*		*Per cent.*		*Per cent.*	
Ca	0.95	18.49	0.90	27.35	1.05	27.54	1.02	26.81
Mg	.13	2.57	.02	.67	.02	.57	.03	.68
Na	.50	9.81	.04	1.15	.04	.94	.06	1.68
K	.04	.70	.01	.36	.02	.63	.02	.63
SO_4	2.31	44.88	2.15	65.67	2.52	66.03	2.48	65.10
Cl	1.13	21.92	.10	2.98	.11	2.88	.14	3.68
KCO_3	.08	1.63	.06	1.82	.05	1.41	.05	1.42
Total	5.14	100.00	3.28	100.00	3.82	100.00	3.80	100.00
$CaSO_4$	3.23	62.84	3.05	93.01	3.58	93.56	3.47	91.05
$MgSO_4$	.03	.66	....	....	....	....	.04	1.05
$MgCl_2$	.49	9.61	.09	2.61	.09	2.25	.07	1.84
KCl	.07	1.32	.02	.67	.04	1.15	.04	1.16
NaCl	1.20	23.32	.04	1.21	.04	1.10	.11	2.95
$NaHCO_3$	.12	2.25	.08	2.50	.07	1.94	.07	1.95
Total	5.14	100.00	3.28	100.00	3.82	100.00	3.80	100.00

This soil is unique among those analyzed in showing a slight but evident increase in the alkali content, especially of the harmful chlorids, as the depth increases and a predominance of magnesium chlorid over the other chlorids in the upper layers of the soil.

Mr. Seidell called the writer's attention to the influence of the composition of the irrigating water on the nature of the alkali.

The rather unusual occurrence of chlorids of the alkaline earths in the water which contains magnesium chloride to the amount of 0.069 per cent is paralleled by the occurrence of the same salts in large amounts in all the surface crusts from Ourlana. There can be no doubt that the composition of the alkali as it now exists in the soil of the date orchards of Ourlana is profoundly influenced by the alkali left in

the soil by the evaporation of the water used for irrigation. Three acre-feet of such water, the least amount needed per annum, would carry on to the land no less than 50,000 pounds of dissolved salts, and, subtracting the excess of gypsum, some 40,000 pounds of harmful alkali, or 0.1 per cent of the surface foot of soil and 0.025 per cent of the 4 upper feet of soil. Of course, some of the water drains off directly, and even leaches alkali out of the soil, but much remains in the soil, and on evaporating leaves the alkali behind.

After a number of years' irrigation with strongly alkaline water such as that of Ourlana a condition of approximate equilibrium is reached between the amount of alkali carried to the land and the amount leached out by the drainage water. The composition of the alkali in a soil in such a condition doubtless depends much more on the composition of the irrigation water than on the character of the alkali originally present in the soil before irrigation was practiced. The influence of the composition of the irrigation water on the nature of the alkali is naturally most clearly marked on lands that are well leached out by means of irrigation for a long period of time with an abundance of water, accompanied with thorough drainage.

A comparison of the composition of the alkali at two such stations, one at Chegga and one at Ourlana, is of interest, because the artesian waters used for irrigation at these two localities contain almost identical amounts of dissolved salts, though of very different composition. The following tabulation shows the proportions of the principal salts in the water and in the surface soil:

TABLE 32.—*Proportions of sulphates and chlorids present in alkali of irrigation water and in well-drained long-irrigated surface soils at Chegga and Ourlana, Algeria.*

Station.	Sulphates in alkali (parts per 100 of total alkali).	Chlorids in alkali (parts per 100 of total alkali).	Total amount of alkali (in percentage of weight of water or soil).
Chegga, artesian water (well by date plantation)	**66.28**	32.53	0.6401
Chegga, surface soil (Station No. 2)	**58.97**	25.64	.39
Ourlana, artesian water (Puits Desveaux)	46.83	**52.08**	.6353
Ourlana, surface soil (Station No. 1)	39.62	**49.06**	.53

It is clear from this table that sulphates preponderate at Chegga, both in the irrigation water and in the alkali of well-drained surface soil after irrigation for a term of years, while at Ourlana the preponderance of chlorids, though not so great as that of the sulphates at Chegga, is nevertheless plainly marked. In both surface soils the approximation in composition of the alkali of the surface soil to that in the irrigation water is evident, and is rendered still more clear by a study of the bases. Magnesium, for example, is decidedly more abundant in the artesian water at Ourlana than at Chegga, and in consequence the surface soils at Ourlana likewise show more magnesium than those of Chegga.

All three Ourlana stations show amounts of alkali large enough to be dangerous to ordinary crops, and, in fact, in this oasis no other cultures were observed such as were followed at the other oases studied, and all three stations show a pronounced surface crust in spite of long-continued irrigation, accompanied with drainage by open ditches. The sandy nature of these soils and their consequent low water content cause the concentration of the soil water to be much higher in proportion to the percentage of alkali present than in heavier soils having a greater water content, such as those of Biskra, for example (see p. 77). There is then every evidence that the date palm is unharmed by these quantities of alkali, even when irrigated by water of very bad quality, full of harmful chlorids.

In Table 33 are given the results of the analyses of the soils from the ten Saharan stations where samples were obtained. The alkali content of the soil is expressed in percentages of the total weight of the soil, as in the preceding pages. All estimated quantities are inclosed in parentheses.

TABLE 33.—*Percentage of alkali in Saharan soils where date culture is possible and in artesian water used to irrigate date plantations.*

Station and depth.	Sulphates.	Chlorids.	Bicarbonates.	Carbonates.	Total alkali.	Remarks.
BISKRA, STATION NO. 1.						
Surface foot	0.05	0.08	0.05	....	0.18	In an old and flourishing date plantation.
Subsoil (12-14 inches)	.05	.08	.06	....	.19	
FOUGALA, STATION NO. 1.						
Surface crust	1.92	9.72	.12	....	11.76	Undisturbed desert soil adjoining young date-palm plantation.
Surface soil (1-12 inches)	.76	4.08	.08	....	4.92	
Subsoil (12-30 inches)	.28	1.46	.10	....	1.82	
Subsoil (30-48 inches)	(.22)	(1.10)	(.08)	....	(1.40)	
Soil (1-4 feet)	(.38)	(1.98)	(.08)	....	(2.44)	
FOUGALA, STATION NO. 2.						
Surface foot	.34	1.56	.08	....	1.98	Young date plantation in good condition.
Subsoil (12-30 inches)	.20	.23	.08	....	.51	
Subsoil (30-48 inches)	.12	.17	.09	....	.38	
Hardpan (48-50 inches)	.09	.04	.08	....	.31	
Soil (1-4 feet)	.21	.54	.084	....	.83	
FOUGALA, STATION NO. 3.						
Surface foot	.09	.08	.09	....	.28	Old flourishing date plantation; soil washed out by continued irrigation.
Subsoil (12-26 inches)	.17	.11	.10	....	.38	
Hardpan (26-28 inches)	.09	.07	.08	....	.24	
Soil (1-4 feet)	(.12)	(.08)	(.09)	....	(.29)	
CHEGGA, STATION NO. 1.						
Surface foot	5.11	.63	.08	....	5.82	Date palms barely able to grow.
Subsoil at 3 feet	1.77	.88	.06	....	2.71	
Soil (1-4 feet)	(2.61)	(.82)	(.07)	....	(3.50)	
CHEGGA, STATION NO. 2.						
Surface foot	.23	.10	.06	....	.39	Washed-out surface soil. Saharan alfalfa grows here.
CHEGGA, STATION NO. 3.						
Subsoil (4-6 feet)	.57	1.22	.07	....	1.86	Formed a solid crust on exposure to air.
OURLANA, STATION NO. 1.						
Surface foot	.21	.26	.06	....	.53	Flourishing date plantation.
Subsoil (12-24 inches)	.16	.17	.04	....	.37	
Subsoil (24-36 inches)	.14	.15	.03	....	.32	
Subsoil (36-48 inches)	.15	.15	.05	....	.35	
Soil (1-4 feet)	.165	.18	.045	....	.392	
OURLANA, STATION NO. 2.						
Surface foot	.20	1.22	.07	....	1.49	Flourishing old date plantation.
Subsoil (30-34 inches)	.20	.20	.08	....	.48	
Soil (1-4 feet)	(.20)	(.445)	(.077)	....	(.72)	
OURLANA, STATION NO. 3.						
Surface foot	.05	.14	.08	....	.27	Dates less vigorous than at Ourlana stations Nos. 1 and 2.
Subsoil (12-26 inches)	.05	.17	.07	....	.29	
Subsoil (26-30 inches)	.09	.22	.07	....	.38	
Soil (1-4 feet)	(.07)	(.19)	(.07)	....	(.33)	
ARTESIAN WATER.						
CHEGGA.						
Well at date plantation	0.4243	0.2082	0.0046	0.0030	0.6401	
OURLANA.						
Puits Desveaux	.2972	.3311	.0040	.0030	.6353	

PREVIOUS AND SUBSEQUENT ANALYSES OF ALKALINE SOILS FROM THE SAHARA.

Two analyses of soil from the vicinity of Ourlana are reported by Rolland.[a] These analyses were not complete, for all the more soluble constituents are lumped as salt, which is here synonymous with alkali. The vegetable soil of a new garden (see analysis No. 23, in Table 34) at Tala em Mouïdi, very near Ourlana (Saharan formation), showed 6.8 per cent of alkali. Another soil (No. 24, Table 34) was from Mazer, about a mile northeast of Ourlana. Here the sample was of washed soil of a salt flat not yet under culture; it contained 3.4 per cent of alkali. The same work reports 7 per cent of alkali in the vegetable soil (No. 21, Table 34) of a garden at Tougourt, 20 miles south of Ourlana, and at Coudiat el Koda, very near Tougourt, no less than 29.5 per cent of the estimated weight of the soil (No. 19, Table 34) of an alkali flat was composed of alkali (see analysis No. 19). The same soil (No. 20, Table 34) washed for two years and put under culture contained only 0.5 per cent of alkali.

TABLE 34.—*Composition (in percentage by weight) of Saharan soils, collected by Rolland.*[1]

Number of analysis.	Nature of sample.	Silica or quartz sand.	Clay.	Peroxid of iron.	Carbonate of lime.	Carbonate of magnesia.	Calcium sulphate.	Salt.[2]	Water and organic matter.	Total.
14	Vegetable soil of a garden at El Golea (quaternary)..	39.0	6.0	3.0	43.0	7.0	0.5	0.6	0.3	99.4
19	Soil of Sebkha (alkaline flat) at Coudiat el Koda, near Tougourt (quaternary) ...	50.0	5.0	1.0	5.0	2.0	5.0	29.5	2.0	99.5
20	Same soil as No. 19 washed for 2 years and put under culture..................	70.0	9.0	1.3	7.0	1.0	5.0	0.5	6.0	99.8
21	Vegetable soil of a garden at Tougourt (quaternary)	48.0	6.0	2.0	9.0	0.7	22.0	7.0	5.0	99.7
23	Vegetable soil of a new garden at Tala em Mouïdi (Saharan formation)......	11.8	55.5	1.3	8.0	1.2	8.0	6.8	7.0	99.6
24	Washed soil of Sebkha (salt flat) not yet under culture at Mazer (modern)........	30.0	26.0	0.3	20.0	....	15.0	3.4	5.0	99.7
16	Soluble portion (84.91 per cent) of Saline incrustation of Sebkha at El Golea (modern)	....	......	.56	....	....	2.95	95.16	1.59	100.26

[1] Rolland, Géologie du Sahara, analyses by École des Mines, Paris.
[2] All the readily soluble salts occurring in these samples are lumped as salt, which is here equivalent to alkali.

None of the soils analyzed for Rolland was selected with any reference to date culture, and it is only from the samples secured by the writer and analyzed by the Bureau of Soils, which have been described above, that any adequate idea can be formed of the ability of the date palms to resist alkali. This power to withstand alkali is one of the most striking among the life-history factors of this tree, since, in this respect, it exceeds all other cultivated plants except possibly the cocoanut palm, which latter is not killed by sea water containing 3.4 per cent of salts in solution.[b]

Mr. O. F. Cook informs the writer that on Cape Mesurado, in Liberia, a Phoenix, perhaps *P. reclinata*, grows on the sea beach nearer to the surf than any other upright vegetation, among the stunted shrubs killed back by the salt spray. The fruit of this palm, though of inferior quality, is eaten by the natives. Hybrids should be

[a] Rolland, Georges. Géologie du Sahara.

[b] Ehrenberg and Hempricht report that on the island of Farsan, in the Red Sea, date palms grow directly out of the crevices in the coral rock, of which the whole island is composed, and although said to be irrigated from springs it may be found that the trees are subject to occasional inundation by sea water.

made between this and the common date palm, in the hope of securing alkali-resistant date palms able to mature fruit near the sea in California.

Through the courtesy of Mr. Thomas H. Means, of the Bureau of Soils, the author is enabled to present the results of the analyses of soils from date-palm plantations of the Oued Rirh country in southern Algeria secured during the trip he and Mr. Thomas H. Kearney made in 1902 for the Office of Seed and Plant Introduction and Distribution.[a] These soil samples, which were collected after the above pages were written, were obtained in the same region as those secured by the writer two years previously, and amply confirm the writer's conclusions as to the extreme resistance of the date palm to alkali. Mr. Means's tabulation is as follows:

TABLE 35.—*Resistance of date palms to alkali at four stations in the Oued Rirh country in the Sahara Desert in Algeria.*

Location.	Condition of palms.	Depth of sample.	Electrolytic determinations of total salts.	Chemical analysis.			Estimated total alkali in soil moisture (gypsum put at 0.06 per cent).[a]
				Total salts.	Gypsum.	Harmful.	
		Inches.					
M'raier	Good	0–12	4.5				
Do	do	12–36	1.4				
Do	do	36–60	.5				
Ourlana	Good; 13 years old	0–12	[b]1.5	4.36	3.45	0.71	0.76
Do	do	12–36	[b].36	4.02	2.20	.82	.88
Do	Good; 20 years old	0–12		4.77	3.79	.98	1.03
Do	do	12–36		4.46	3.89	.57	.62
Do	do	36–54		4.63	3.53	1.10	1.15
Do	do	(1–4 ft.)					.86
Ourir	Fair	0–12		6.99	2.38	4.61	4.66
Do	do	12–26		4.82	3.90	.92	.97

[a] This column has been added to Mr. Means's table, and shows the amount of alkali, counting calcium sulphate at 0.05 per cent in accordance with the method outlined on p. 74. These sums may be compared with the analyses reported on the preceding pages and with the alkali content of soils determined by the electric method.

[b] In regard to the seeming discordance between the results of the determination of the amount of alkali by the electrical and chemical methods, Mr. Means writes as follows: "The apparent discrepancy between the total solids as determined by the bridge and by chemical analysis in the samples collected from 13-year-old palms at Ourlana is due to error in sampling, for the sample sent to the laboratory was collected from a different hole from the sample determined by the bridge."

The amount of harmful alkali is very high in these soils, higher in fact than in any of the soils collected by the writer except at Chegga, Station No. 1, and Fougala, Station No. 1. These newest analyses demonstrate anew the remarkable alkali resistance of this wonderful palm and show that it is perhaps more resistant than the writer's soil samples seemed to indicate, and make his estimates of its probable resistance conservative, to say the least.

DRAINAGE WATER FROM ALKALINE SOILS USED TO IRRIGATE DATE PALMS IN THE SAHARA.

It is a remarkable fact, showing the high resistance of the date palm to alkali, that drainage water is used to irrigate date palms even in the Oued Rirh region, where the artesian water is strongly brackish as it flows from the well, and where in addition it must seep through the very alkaline soil before reaching the drainage ditches. Such palms are said to be less vigorous and to yield less fruit. There are several date plantations in the oasis of Tozeur, in the Tunisian Sahara, which are irrigated exclusively by water from the drainage ditches of gardens

[a] See Yearbook of the Department of Agriculture, 1902, p. 573.

situated on higher land.[a] These plantations are so low that drainage is impossible, and naturally the growth is poorer and the yield lower than in better situations, but it is remarkable that even date palms should be able to grow at all in such situations.

ALKALI CONDITIONS IN RELATION TO DATE CULTURE IN THE SALT RIVER VALLEY, ARIZONA.

A recent soil survey of the Salt River Valley region made by Thos. H. Means[b] shows that there are considerable areas, perhaps 1 per cent of the land in the valley, where the amount of alkali in the soil is from 0.25 to 0.50 per cent, or enough to be dangerous for most crop plants, and much more, perhaps 5 per cent of the land, contains over 0.5 per cent where none but alkali-resistant crops can grow. Most of these alkali spots are caused by the rise of the ground water in the lowest levels, as a result of irrigation, until it comes so near the surface that moisture reaches the surface and alkali is carried up from the subsoil by the capillary currents of water. Such ground water has leached from higher levels and is often charged with considerable amounts of alkali.

The water used to irrigate the Salt River Valley is diverted from the Salt River and conducted to the fields in open ditches. The river is low during summer and the water often contains a considerable amount of harmful alkali in solution. Prof. R. H. Forbes, who made a study of the water of the Salt River from August 1, 1899, to August 4, 1900, finds that from June 1 to August 4, 1900, the average content of soluble salts was 139 parts per 100,000, of which only 8.2 parts per 100,000 consisted of the harmless gypsum, leaving 130.8 parts per 100,000, or 0.13 per cent of harmful alkali. Professor Forbes remarks that "it is to be remembered that this year (1900) was exceptionally dry, and the waters were consequently concentrated for a longer than usual time. Nevertheless, for a considerable portion of each year these waters are low and salty in character, and it remains true that their use (which is unavoidable) must be attended with remedial care."[c]

Professor Forbes considers it probable that with the prevailing agricultural practice of Arizona the use of irrigating water containing 100 parts of soluble salt per 100,000 is likely in a few years to cause harmful accumulations of alkali. In view of this danger the great value of the date palm is obvious, since it can support very much more alkali than is sufficient to kill other crop plants.

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[a] Masselot F. Les dattiers des oasis du Djerid. In Bul. de la Direction de l'Agric. et du Commerce, Régence de Tunis, Vol. 6, No. 19, April, 1901, p. 132.

[b] Means, Thos. H. Soil Survey in Salt River Valley, Arizona, Field Operations of the Division of Soils, U. S. Department of Agriculture, 1900, pp. 287–332.

[c] Forbes, R. H. Bul. 44, Arizona Agricultural Experiment Station, Tucson, 1902, p. 166.

As was noted on page 86, water as alkaline as this is without any direct effect on the date palm and could be injurious only by leading to the accumulation of alkali in badly drained soils after many years of heavy irrigation.

A sample of surface crust from an alkaline spot south of Tempe, Ariz. (sec. 3, T. 1 S., R. 4 E.), near where the Cooperative Date Garden (Pls. XXI, XXII, and fig. 6, p. 36) is located, shows the following relative amounts of alkali soluble in excess of water (50 grams of soil to 1,000 grams of water), which may be compared with the analyses of crusts from the Sahara and from the Salton Basin (p. 134):

TABLE 36.—*Percentage composition of alkali (soluble in excess of water) in surface crust from near Tempe, Ariz.*[a]

Calcium sulphate	1.56
Magnesium sulphate	3.04
Sodium sulphate	8.98
Sodium chlorid	59.72
Potassium chlorid	12.18
Sodium carbonate	4.14
Sodium bicarbonate	10.38
Total per cent of weight of soil	2.56

The surface soil (1 to 12 inches in depth) from the same station shows the following amounts of alkali stated in per cents of the weight of the soil:

TABLE 37.—*Per cent of alkali in surface soil from Tempe, Ariz.*[b]

Calcium sulphate	0.06
Magnesium sulphate	.06
Sodium sulphate	.22
Sodium chlorid	1.53
Potassium chlorid	.23
Sodium carbonate	.06
Sodium bicarbonate	.32
Total	2.48

It must be remembered that in the Cooperative Date Garden at Tempe the roots doubtless reach a subsoil containing much less than this amount of alkali. Most of the alkali spots in the Salt River Valley can be planted profitably to date palms if care be taken in irrigating (see chapter on drainage, p. 50). Near the date garden alfalfa was killed by the rise of alkali a few years ago, and even pear trees showed evident signs of distress, while a date palm growing alongside was entirely unaffected by the alkali.

[a] Analyses quoted from Thos. H. Means, Field Operations of the Bureau of Soils, Second Report, 1900, p. 320.

[b] Calculated from an analysis reported by Means, l. c., p. 320.

It should be noted that the alkali occurring in many parts of the Salt River Valley, represented by this sample, is of a different type from that found in the Algerian Sahara and in the Salton Basin, California. In the last-named regions the alkali is of the "white" kind and contains only very small percentages of carbonates or bicarbonates. In the Salt River Valley sample, on the contrary, the alkali is of the so-called "black" sort, and contains an appreciable amount of the highly poisonous sodium carbonate, which is much more injurious to most plants than is "white alkali." Black alkali is intensely alkaline in reaction,[a] and because of this reaction is highly corrosive to the roots of plants. It also has the property of dissolving the humus of the soil, which causes the formation of black crusts and of black spots in the fields where this type of alkali is abundant; whence the name.

From the thrifty growth of the date palms in the Cooperative Date Garden at Tempe, Ariz., in soils approximating the above sample in the amount and nature of their alkali content, it is probable that the date palm is able to resist small quantities of black alkali. Further researches are, however, needful to settle this point. (See p. 120.)

ALKALI CONDITIONS IN RELATION TO DATE CULTURE IN THE SALTON BASIN, CALIFORNIA.

GEOGRAPHY AND GEOLOGY OF THE SALTON BASIN.

The Salton Basin, or Colorado Desert, (see Pl. IV, p. 122, fig. 10, p. 102, and Pl. XVIII, fig. 1),[b] is a basin the center of which is far below sea level (some 263 feet below at Salton). It is surrounded by mountains on three sides, and is limited on the south by sedimentary deposits of the delta of the Colorado River which have piled up considerably above the sea level. The high San Jacinto Mountains on the west effectually protect the basin from the cold and humid winds from the Pacific Ocean, while the still higher San Bernardino Mountains form a barrier on the north that stops the cold winds that sweep across the Mohave Desert; on the east, San Bernardino and the lower Chocolate Mountains limit the basin.

That part of the Salton Basin which lies below sea level was covered until comparatively recent times by the Gulf of California, which then extended much farther north than now. The Colorado River, which then flowed into the gulf near where Yuma is now situated, brought down at flood times an enormous mass of sediment, which gradually

[a] Alkali, in spite of its name, is often composed of neutral salts, such as sulphates and chlorids, and has in consequence no pronounced alkaline reaction. (See p. 72.)

[b] See also Pls. LXXXVII to XCV, Means and Holmes, Soil Survey around Imperial, Cal., in Field Operations of the Bureau of Soils, Third Report, 1901; also Pls. XXIII to XXVI, Coville and MacDougal, Desert Laboratory of the Carnegie Institution, Publication No. 6, Carnegie Institution of Washington, November, 1903.

Fig. 10.—Sketch map showing the Salton Basin and the easily irrigable lowlands in the Colorado River Valley in Nevada, Arizona, and California. The area inclosed by the dotted line is below sea level. Based chiefly on maps of Lieutenant Ives and of the International Boundary Commission.

built a bar across the narrow gulf and cut off the upper portion, now the Salton Basin, from the sea.[a]

Barrows says:[b]

All this took place in very recent times. The Coahuila Indians, who to-day inhabit the upper end of the valley, have a distinct and credible tradition of the drying up of this lake and of the occasional sudden return of its waters, and the Dieguenos, who lived at a time when the supply of water along the central portion of the valley was probably much greater than at present, raised on the naturally irrigated soil abundant crops of maize, melons, and beans. But slowly the valley was abandoned to aridity. Almost unvisited by rainfall, except about the edge of the mountains, the loss of the river left it cruelly dry. Low, and inclosed between heat-reflecting ranges that shut off the breezes of the ocean, it gained a temperature which is one of the highest on the globe. The windstorms that rage up the valley from the southeast have drifted great dunes of sand over certain portions, and much of the country never reached by the deposits of the lake is as black, stony, and repulsive as eruptive rock formations in the desert can be. Apparently about the middle of the first half of the century the overflow from the Colorado was largely checked and not resumed to any extent until the year 1849. The Indians, who had lived in plenty along the central valley, were driven by the drought forever from their homes.

During the high flood of the Colorado River in June and July the water breaks through its banks near Algodones, in Mexico, a few miles below Yuma, and flows westward through an old channel for some thirty miles; then, turning north into the United States, it flows through the Salton River to Salton Lake, filling up Mesquite Lake on the way. Most of the stream, however, goes on to Lake Jululu, or Volcano Lake, from which the New River flows northward to Salton Lake, and the Hardy River southward to the Gulf of California (see fig. 10). The Salton and New rivers flow only during the highest floods, but the Hardy River flows all the year, being fed by the Rio Padrones.

The Maquata Basin, a region similar to the Salton Basin, and, like it, lying below sea level, lies to the west of the Cocopah Mountains in Mexico. It is usually a waterless desert, but, at times of very high flood in the Hardy River, water flows around the mountain range, creating the Laguna Maquata[c] (see fig. 10) in the center of the basin. This is probably the only region in Mexico which, when irrigated, will be suitable for the culture of the best sorts of dates.

[a] Some students of this region believe that an upheaval of the region covered by the delta aided in cutting off Salton Basin from the Gulf of California. The occurrence of mud volcanoes and of extinct craters, such as the Sierra Prieta, lends strength to the view that the piling up of such enormous masses of sediment has induced geologic changes. The old beach lines of the Salton Basin are, however, still approximately at sea level, which would go to show that there has been but slight change in the level of the region as a whole since it was cut off from the sea. (See Barrows, David P., The Colorado Desert, in National Geographic Magazine, Vol. XI, No. 9, September, 1900, p. 340.)

[b] L. c., p. 341.

[c] Barrows, l. c., p. 344.

The greater part of the Salton Basin is as level as a floor and almost as destitute of vegetation (see Pl. XVIII, fig. 1), which renders it an exceptionally favorable region to put under irrigation, since in most places no leveling is required and very low dikes serve to retain the water.

The geographical position of Salton Basin is indicated by figure 10, its general character is shown in Plate XVIII, figure 1, and a detailed soil map, showing types of soil and the amount of alkali present, is given in Plate III, page 106. The location of the area shown in Plate III is indicated by the ruled space in figure 10, page 102.

Many schemes have been broached for the irrigation of the Salton Basin since it was first surveyed in 1854. Since 1891 Mr. C. R. Rockwood, of Los Angeles, Cal., has been making surveys and persistently endeavoring to interest capital in irrigating this region. His efforts have resulted in the formation of a company which in 1901 carried the first water into the lower part of the Salton Basin.[a] Land and irrigation companies formed at the same time and, working in cooperation with the company mentioned, pushed energetically the sale and development of the land irrigated by the water, and now in 1903 some 100,000 acres are under irrigation and it is planned to extend the canals so as ultimately to irrigate most of the basin below the sea level, some 500,000 acres in all.

The main diversion works are at Hanlon's Heading, some 7½ miles below Yuma, whence the water is conducted about 8 miles to the channel of the Salton River, which is used to carry the water 60 miles to the northwest, where at the international boundary line it is turned into a 60-foot canal with a capacity of 5,000 second-feet, intended to irrigate all the lands lying between the Salton and New rivers. After entering the United States for a short distance this large canal is divided into two 30-foot canals running side by side, the object being to use one while the other is being cleaned. The courses of the lateral canals are shown in the map on Plate III. Other main canals are planned to conduct the water from the Salton channel to irrigate land in Mexico as well as lands in the Salton Basin in California lying east of Salton River and west of New River[b] (see figure 10, p. 102).

WATER SUPPLY OF THE SALTON BASIN.

The greater part of the Salton Basin can be watered from the Colorado River, and a large area in the basin, from Calexico, on the Mexican boundary, to Imperial, Brawley, and northward, is now irrigated

[a] Means, Thos. H., and Holmes, J. Garnett. Soil Survey around Imperial, Cal. In Field Operations of the Bureau of Soils, U. S. Department of Agriculture, Third Report, 1901, p. 588.

[b] Means and Holmes, Soil Survey around Imperial, Cal., Field Operations of the Bureau of Soils, U. S. Department of Agriculture, Third Report, 1901, pp. 588, 589.

by means of water conducted from near Yuma, as above described. Fortunately, the Colorado River water is of remarkably good quality, although this stream flows for hundreds of miles through arid regions and many of its tributaries drain highly alkaline deserts. An extensive set of analyses was made by Prof. R. H. Forbes for the period from January 10, 1900, to January 24, 1901,[a] during which time the content in soluble salt of the river water at Yuma varied from 21 to 125 parts per 100,000, or from 0.021 to 0.125 per cent. During the low stages of the river in winter, early spring, and late in summer, the alkali content runs about 90 parts per 100,000. For two months (from May 25 to July 27, in 1900), during the flood caused by the melting of the snows of the Rocky Mountains, less than 27 parts of soluble salt in 100,000 were observed. On the other hand, during a smaller sudden rise in October, due to torrential downpours on the Arizona watershed, the alkali content rose markedly, averaging 105 parts per 100,000 from September 26 to November 19. This decided increase in the soluble salt content of the water was doubtless occasioned by the washing of salts out of the desert soil into the Arizona rivers and its subsequent drainage into the Colorado River. During the year 1900 the Colorado River water contained less than 100 parts of salts per 100,000 of water during 315 days and more than 100 parts per 100,000 during only 50 days.

During the growing and fruiting season of the date palm, from April 15 to September 15, inclusive, when four-fifths of the water needful for the whole year must be applied, the soluble salt content ranges from 0.021 to 0.068 per cent, or from 21 to 68 parts in 100,000 of water; while for two months during the flood, when water is most abundant for irrigation purposes and consequently most easily spared for washing alkali out of the soil, the alkali content is only about 27 parts per 100,000, or 0.027 per cent.

A considerable part of the soluble salts held in solution consists of harmless (if not beneficial) gypsum, which varies but slightly during the year, making up from 5.6 to 8.6 parts per 100,000, which would reduce the harmful alkali content during the summer months to about 14 to 60 parts per 100,000, and to 20 parts per 100,000 during the two months of flood in May, June, and July. Such small amounts of alkali in irrigation water are without harmful influence.

The relatively high purity of the Colorado River water is shown best by a comparison with that used to irrigate the flourishing date gardens of the Sahara. At Biskra the amount of soluble salt varies from 75 to 235 parts per 100,000, and is highest in summer, when the palms need most water. At Chegga, Algeria, the soluble salt

[a] Forbes, R. H. The River Irrigating Waters of Arizona—Their Character and Effects. Bul. No. 44, Arizona Agricultural Experiment Station, Tucson, 1902, p. 202.

content of the artesian water is no less than 640 parts per 100,000, and after subtracting gypsum there remain 434 parts per 100,000 of harmful alkali—0.434 per cent, or 250 grains to the gallon. At Ourlana, Algeria, very extensive and flourishing plantations are irrigated from a flowing artesian well (Puits Desveaux), where the water contains 635 parts per 100,000 of soluble salt and 403 parts per 100,000 of harmful alkali.

The Colorado River water is better than that used to irrigate the famous Salt River Valley of Arizona, and has the advantage of having the lowest alkali content in summer, whereas just the reverse is true of the Salt River water (see p. 99).

The water of the Colorado River carries, both in solution and in suspension as fine silt, fertilizing materials of considerable value, consisting principally of potash, nitrogen, and phosphoric acid. The soils of the Salton Basin are at present so rich that they do not need the fertilizers thus carried to the land by the irrigating water, but such fertilizing substances deposited by the water will serve to keep up the fertility in the future even under heavy cropping. Even now the phosphoric acid brought by the Colorado River water (see p. 114) is doubtless decidedly beneficial to the soils of the Salton Basin, which contain but very small amounts of this very necessary plant food.

SOIL CONDITIONS IN THE SALTON BASIN.

The soil conditions existing in the greater part of the Salton Basin are shown by Means and Holmes, of the Bureau of Soils, [a] who made surveys in 1901 covering some 108,100 acres lying between the New and the Salton rivers (fig. 10 and Pl. III), comprising the larger part of the basin as yet put under irrigation. This area is shown on Plate III. The same classes of soils and the same general condition of alkalinity prevail over the greater part of the Salton Basin.[b]

In the portion of the basin surveyed by Means and Holmes five types of soils were recognized. The areas occupied by these types are shown in Table 38.

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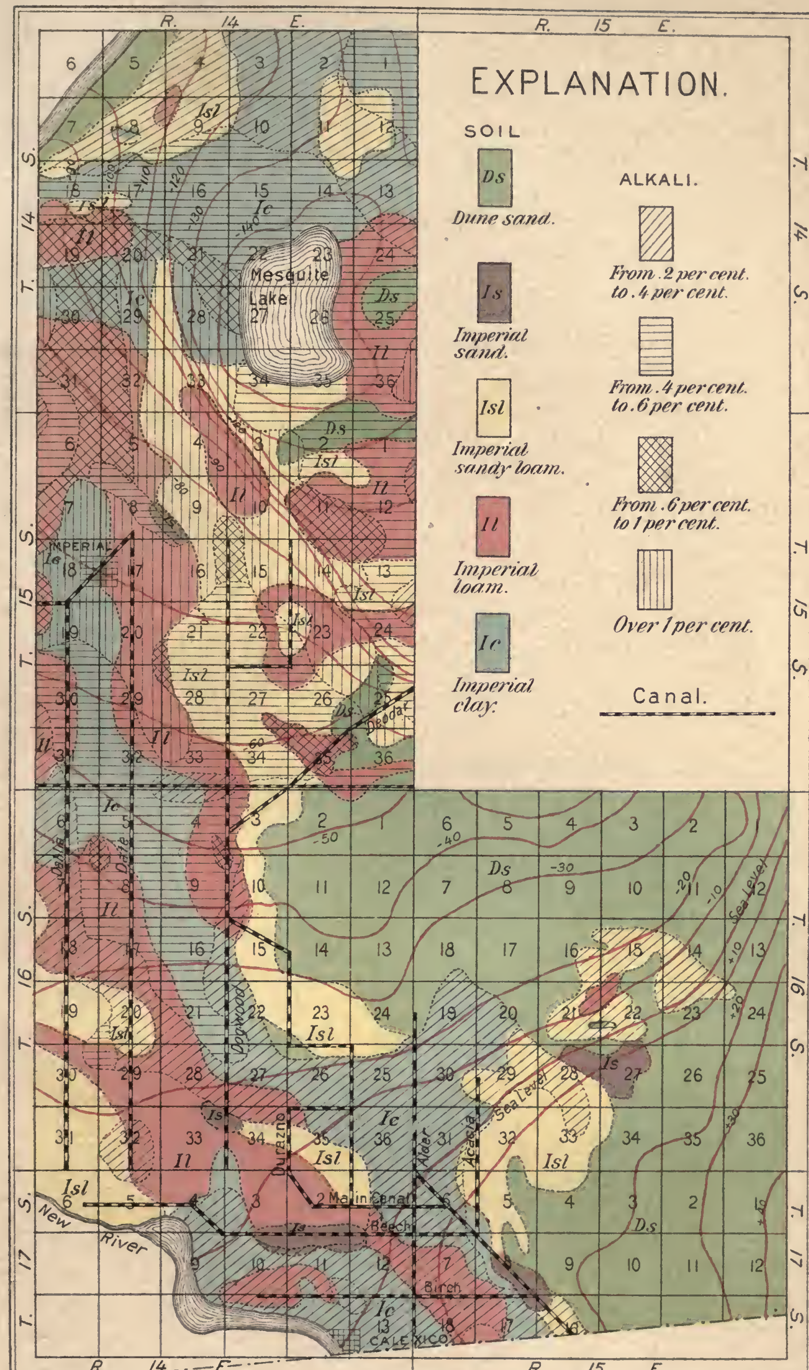
[a] Circular 9, Bureau of Soils, January, 1902, and Field Operations of the Bureau of Soils, U. S. Department of Agriculture, 1901, pp. 587–606, map 29.

[b] The University of California also investigated the soil conditions in the Salton Basin, and in February, 1902, published a valuable report on this region (Snow, Frank J., Hilgard, E. W., and Shaw, G. W., Lands of the Colorado Delta in the Salton Basin, Bul. 140, Cal. Agr. Exp. Sta., pp. 51, with supplement by Joseph Burtt Davy, The Native Vegetation and Crops of the Colorado Delta of the Salton Basin, April, 1902, pp. 8).



Soils surveyed by Bureau of Soils. GRAY LITH. CO. N.Y. Contour Interval 10 Feet.

MAP SHOWING DISTRIBUTION OF SOIL TYPES AND OF ALKALI IN THE IMPERIAL AREA, IN THE SALTON BASIN, CAL.

TABLE 38.—*Areas of different soils surveyed in the Salton Basin around Imperial, Cal.*

Soil type.	Area.	Per cent of area surveyed.
	Acres.	
Dunesand	29,840	27.7
Imperial sand	1,020	1.0
Imperial sandy loam	23,710	21.9
Imperial loam	30,410	28.0
Imperial clay	23,120	21.4
Total	108,100	100.0

The alkali content of the surveyed land is shown in Table 39.

TABLE 39.—*Alkali content of soils surveyed in Salton Basin around Imperial, Cal.*

Alkali content.	Area.	Per cent of area surveyed.
	Acres.	
Less than 0.2 per cent	42,220	39.1
From 0.2 to 0.4 per cent	25,320	23.4
From 0.4 to 0.6 per cent	23,040	21.3
From 0.6 to 1 per cent	5,220	4.8
From 1 to 3 per cent	5,670	5.3
3 per cent and over	6,630	6.1

Dunesand consists of reddish-brown sand, rather rotten, and often mixed with small particles of flocculated soil. It is blown by the wind into small dunes, usually crescent-shaped and 2 to 10 feet high. The dunes are underlain by the heavier soils of the basin. This soil is mostly free from alkali, but the land is not now occupied for agricultural purposes because of the heavy expense necessary to level it to render it fit for irrigation. This expense is variously estimated at from $20 to $30 an acre, and in view of the preference of the date palm for sandy soils, it may prove in future a profitable investment to level such land and plant it to the choice varieties of date palms. This dunesand area, as may be seen from the maps, is of considerable extent.

The small area of level Imperial sand is also free from harmful quantities of alkali and would be very useful for date culture. The amount of such land is small, however, and it will probably be used for truck crops sensitive to alkali.

The Imperial sandy loam soil is formed by the coarsest particles of the Colorado River deposit mixed with wind-blown sand. The sandy loam extends to a depth of 3 feet and is underlain by a loam or heavy loam. This soil will take water readily, and where level and free from alkali is adapted to cultivated crops or alfalfa. Some of the best and some of the worst lands of the valley are composed of this type.[a]

The Imperial sandy loam occupies over one-fifth of the surveyed area in the Salton Basin and is probably the soil on which the date palm will succeed best, as it is on such land that it grows best in the Sahara.

[a] Means and Holmes. Field Operations of the Bureau of Soils, U. S. Department of Agriculture, 1901, p. 594.

About three-quarters of the area occupied by this type of soil contains less than 0.6 per cent of alkali, which amount is absolutely without harmful effect on the date palm. It will probably grow nearly as well on an additional 10 per cent of the land even without drainage, and could struggle along on 10 per cent more of the area, while if drainage were provided doubtless the whole area of sandy loam could be planted to date palms.

The Imperial loam soil has a smooth surface as level as a floor and almost devoid of vegetation.

It has the peculiar slick, shiny appearance often seen in localities where water has recently stood. It is the direct sediment of the Colorado River, which was deposited in strata when the area was under water. These strata are from 0.01 inch to 2 or 3 inches thick, very much resembling shale; in fact, to all external appearances being exactly similar. When water is applied, however, the soil softens up and is a reddish, sticky loam, a little heavier than a silt loam. It is from 4 to 6 feet deep, underlain by a clay or clay loam, and contains considerable organic matter, including an abundance of nitrogen and potash. When free from alkali it is well adapted to the growing of wheat, barley, and alfalfa.[a]

The Imperial loam is much like the heavy soils in the oases at the northern edge of the Sahara, in Algeria, and is well adapted to the date palm if properly irrigated to prevent its becoming too dry and if kept in a proper state of tilth to prevent packing. This soil is very alkaline in the region surveyed in the Salton Basin, but about 60 per cent of the area covered by this soil has less than 0.6 per cent of alkali, and an additional 10 per cent will support the date palm nearly as well, making 70 per cent of the land where this plant will be unhampered by alkali. The date can grow, though less vigorously, on an additional 15 per cent of the area, though it may not fruit well unless drainage be provided and some of the alkali washed out.

The Imperial clay soil (Pl. XVIII, fig. 1) is found as a surface soil or as subsoil at greater or less depth throughout the surveyed area.

It is usually comparatively level, although in some places small hummocks have been blown up on its surface. It is this soil that surrounds both the towns of Calexico and Imperial, the only difference in the soils of the two districts being in the alkali content. The soil has been formed by the deposition of the finest sediment of the Colorado River, and is stratified in the same way as the loam. It is a heavy, sticky, plastic soil, very much resembling the clay subsoil found in the Mississippi River Delta. When dry and in its natural state, it exists in hard cakes and lumps, which may be cut with a knife and are susceptible of taking a high polish. When wet, the lumps are very plastic and sticky, making a soil which is very refractory and difficult to cultivate. Upon drying, the soil becomes very hard and cracked. Sorghum and millet were grown this year on several hundred acres of this land in the vicinity of Calexico, and produced good crops. The sorghum, however, was the best, the yield being 6 or 8 tons to the acre.

Cultivation of this clay soil will be very difficult. A similar soil is found in the Salt River Valley as a phase of the Glendale loess, and is locally known as "slick-

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[a] Means and Holmes. Field Operations of the Bureau of Soils, U. S. Department of Agriculture, 1901, p. 595.

ens." The farmers of that neighborhood have considerable difficulty in managing this soil, and it is not as refractory as much of the Imperial clay. Either annual crops or crops which can be cultivated throughout the growing season are productive of best results on this soil, for the heavy and hard crusts need to be broken up and thoroughly pulverized occasionally. Alfalfa does not do well on such soil, for the crusts seem too hard and the soil too dense and impenetrable to permit the constant extension of the fine rootlets so essential to permanency in an alfalfa field. Deep plowing and thorough cultivation will in a few years greatly improve this soil.[a]

Practically none of the heavy clay soil is free from alkali, but some 45 per cent of this land in the surveyed area carries less than 0.4 per cent of alkali,[b] and about 25 per cent more of the area occupied by Imperial clay has from 0.4 to 0.6 per cent of alkali, where the date will succeed as well, making some 70 per cent of this soil available for the most remunerative date culture. The date palm can grow, but will fruit less on 7.5 per cent more of the clay land even without drainage, making in all about 77.5 per cent of this soil that is immediately available for date culture. The date can struggle along even without artificial drainage on, perhaps, 75 per cent more of the area.

The observations of Mr. D. G. Fairchild near Bassorah, on the Shat-el-Arab River, at the head of the Persian Gulf, show that these great date plantations, the most extensive in the world, are on "as pure an adobe as the clay of a brickyard,"[c] and indicate the probability that dates may be grown successfully on any heavy soils, provided the soils be adequately drained and aerated.

In the Bassorah date region the soil is automatically watered, drained, and aerated by a system of ditches which fill from the river at high tide and drain out again at low tide.

In the Salton Basin and elsewhere in the United States it is probable that drainage ditches or tile drains will be necessary to permit the proper utilization of the heaviest clay soils.

Messrs. Means and Holmes say: "Of the lands which are level enough to permit profitable irrigation 17 per cent have 0 to 0.2 per cent of alkali, and are at present safe for cultivation to all ordinary crops; 32 per cent have 0.2 to 0.4 per cent of alkali, which is risky for ordinary crops; the remaining 51 per cent are too alkaline to be taken up for any but alkali-resistant crops." That is to say, only 49 per cent of the irrigable land in the surveyed area of the Salton Basin is suitable for growing ordinary crops, whereas 76 per cent is available for date culture.

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[a] Means and Holmes. Field Operations of the Bureau of Soils, U. S. Department of Agriculture, 1901, pp. 595, 596.

[b] In soils of this nature, having a very fine texture and consequently a high water capacity, a given percentage of alkali is not so injurious as in a sandy soil of low water capacity, for the reason that the alkali forms a more dilute solution in the soils which hold more water. (See p. 75.)

[c] Fairchild, D. G. Persian Gulf Dates and Their Introduction into America. Bul. No. 54, Bureau of Plant Industry, U. S. Department of Agriculture, 1903.

To summarize, the date palm can grow on the following areas in the surveyed region without any especial provision being made for drainage:

TABLE 40.—*Area of lands in the surveyed portion of the Salton Basin suitable for date culture.*

Kind of soil.	Total irrigable area.	Area where date palms will be unaffected by alkali.	Area where date palms will grow and fruit without artificial drainage, but less vigorously.	Area where date palms will be able to struggle along but not to fruit well unless artificial drainage is provided.	Per cent of total irrigable area immediately available for date culture without artificial drainage.	Additional percentage of total irrigable area where date palms can grow but not fruit well without drainage.
	Acres.	*Acres.*	*Acres.*	*Acres.*		
Imperial sand	1,020	1,020	....	....	100	....
Imperial sandy loam	23,710	17,800	2,400	2,300	85	10
Imperial loam	30,410	18,300	3,000	4,500	70	15
Imperial clay	23,120	16,200	1,800	1,800	77.5	7.5
Total	78,260	52,320	7,200	9,800	76	12.5

In all some 59,520 acres, or 76 per cent of the 78,000 acres of surveyed land level enough to permit irrigation, is immediately available for profitable date culture without artificial drainage, while the date palm will grow on an additional 12.5 per cent of the land, though it probably will not fruit well unless the soil is drained.

With proper drainage almost all the surveyed area except about 3,000 acres of clay soil could be rendered suitable for date culture by washing out the alkali. Only 6 out of 156 borings made by Messrs. Means and Holmes showed a percentage of alkali so high as to be dangerous to the life of the date palm.

The immense importance of date culture for this region becomes at once apparent. It is the only profitable culture that can be followed on a quarter of the irrigable area too alkaline for other crops, while the climatic, soil, and water conditions are here so favorable for the date palm (see pp. 52 to 72) that it will pay to plant the choice sorts even on the best lands where many other crops would succeed.

It becomes of the greatest importance to introduce the Deglet Noor date into this region, where all the conditions combine to render its culture profitable, and where at the same time it is necessary in order to utilize a large part of the area already occupied and irrigated.[a]

[a] Very recently (March, 1904), since this bulletin was sent to the Printing Office, the Department of Agriculture has established, in cooperation with the California Experiment Station, an experimental date garden in the Salton Basin at Mecca, Cal. [Mecca was called Walters until January, 1904, and is so shown on all old maps and on fig. 10, p. 102.] At the same time a large number of offshoots of the best sorts of date palms (including many of the Deglet Noor variety) were ordered from the principal centers of date culture in the Algerian Sahara. In addition, several large Deglet Noor palms are being transplanted bodily, with large balls of earth about the roots, from Tempe, Ariz., in order to test as soon as possible the ability of this variety to fruit in the Salton Basin.

In the northern part of the Salton Basin around Indio and Walters, Cal., there are flowing artesian wells; in this and in many other respects the conditions of the Oued Rirh region in the Sahara are almost exactly reproduced. It is probable that date culture will prove even more profitable here than in the Oued Rirh country, since the summers are hotter in the Salton Basin, which will insure that the Deglet Noor variety will mature its fruit completely every year. The soils of this part of the Salton Basin have not yet been studied with reference to their alkali content, but it is known that there are large areas of land which could be irrigated by artesian wells where there is so much alkali that the growing of ordinary crops is prevented.[a] On such areas the culture of the date palm is likely to be the only paying industry that can be followed.

ALKALI CONDITIONS AT PALM CANYON, IN THE FOOTHILLS BORDERING THE SALTON BASIN.

The California fan palm (*Neowashingtonia filifera*) grows wild in the foothills surrounding the Salton Basin wherever the soil is sufficiently moist. In some respects the fan palm is much like the date palm, for it needs a constant supply of water at the roots, it delights in hot, dry weather, and can resist a large amount of alkali. An old fan palm produces in a good season from 50 to 200 pounds of fruit, according to Dr. Welwood Murray. The fruit is very small, of a pleasant flavor, and it is not unlike a miniature date. Natural groves of these palms as they occur in the foothills to the north of Indio are shown on Plate XIX, figures 3 and 4.[b]

Dr. Welwood Murray has kindly collected a series of soil samples in the groves at Palm Canyon, near Palm Springs, Cal. These samples were analyzed through the kindness of Prof. Milton Whitney, chief of the Bureau of Soils, and the results are given herewith, calculated in the same way as for the soil samples from the Sahara.

TABLE 41.—*Per cent of alkali in soils in which California fan palms were growing at Palm Canyon, California.*

Station.	Locality and depth.	Calcium sulphate.	Magnesium sulphate.	Sodium sulphate.	Sodium chlorid.	Potassium chlorid.	Sodium carbonate.	Sodium bicarbonate.	Total alkali.
A1	Surface soil and crust, flowing water near by.	0.02	1.09	12.88	2.98	0.113	0.09	0.26	17.45
A2	Surface soil	.05	.078	....	.214	.156	....	.143	.66
B	Subsoil, about 2 feet deep	.04	.078	.227	.127	.014	....	.116	.60
C	Subsoil, about 4 feet deep	....	....	....	....	....	....	....	.25
D	Subsoil, sample taken from between roots of a full-grown fan palm.	.02	.266	4.52	.696	.088	Tr.	.212	5.80

[a] Recently J. Garnett Holmes, of the Bureau of Soils, United States Department of Agriculture, has surveyed this area, and his report will soon be published.

[b] See also Plates XXV and XXVI, in Coville and MacDougal, Desert Botanical Laboratory of the Carnegie Institution. Plate XXVI in particular gives an excellent idea of the appearance of the fan-palm oases as seen from a distance.

Sample D is the most interesting, as it shows the ability of the roots of the fan palm to grow in enormously alkaline soil.

A recalculation of sample D in comparison with the surface soil of Station No. 1 at Chegga, Algeria, the only sample obtained in the Sahara with so high an alkaline content, is given herewith.

TABLE 42.—*Per cent of alkali in soil at Palm Canyon, California, and at Chegga, Algeria.*

Locality and depth.	Sulphates.	Chlorids.	Bicarbonates.	Total.
Palm Canyon, Station D, subsoil at 6 feet depth, full of palm roots	4.806	0.784	0.212	5.80
Chegga, Station 1, surface soil	5.11	.63	.08	5.82

No subsoil in the Sahara or from the Salton Basin as yet reported is so alkaline as the subsoil from Palm Canyon. There are no roots very near the surface, where the amount of alkali is greatest, at Chegga (or at the other Saharan stations), whereas the layer in question in Palm Canyon is full of roots. Prof. R. H. Forbes[a] has called attention to the occurrence of roots of the date palm at 6 feet in depth in "very alkaline subsoil" in the Salt River Valley, Arizona, where they were forcing their way into the calichi hardpan. The date palm doubtless can stand as much alkali as the fan palm, and it is probable that it would grow where the fan palm is now found wild.

The summer heat will doubtless be less than in the lower parts of the Salton Basin, for these fan palms occur some 500 feet or more above sea level. The winters are, on the other hand, warmer at such altitudes, if there is a good drainage of cold air to lower levels (see p. 61).

CHEMICAL COMPOSITION OF THE ALKALI OF THE SALTON BASIN.

An analysis of a mixture of eight surface crusts was reported in 1901 by Means and Holmes, which analysis is given below alongside that of six surface crusts obtained in 1900 in the Algerian Sahara.

TABLE 43.—*Percentage composition of alkali in surface crusts from the Algerian Sahara and from the Salton Basin, California.*

Locality and station.	Calcium sulphate.	Magnesium sulphate.	Sodium sulphate.	Magnesium chlorid.	Potassium chlorid.	Sodium chlorid.	Sodium bicarbonate.	Sodium carbonate.	Sodium nitrate.	Total percent of weight of soil.
Fougala No. 1	32.38	2.41	8.35	....	3.08	53.06	0.72	....	....	17.33
Fougala No. 4	25.26	5.60	36.71	....	2.69	28.77	.97	....	....	15.03
Chegga No. 1	5.85	2.62	86.49	....	.23	4.47	.25	0.09	....	64.13
Ourlana No. 1	22.13	18.39	....	4.91	1.99	51.78	.80	....	....	14.52
Ourlana No. 2	26.47	13.94	....	3.27	.60	55.05	.67	....	....	18.43
Ourlana No. 3	62.84	.66	....	9.61	1.32	23.32	2.25	....	....	5.14
M'raier	8.27	21.86	15.83	....	1.74	51.82	.48	....	....	56.32
Sahara, average of 7 samples	26.17	9.35	[b]21.05	[b]2.54	1.52	38.32	.88	[b].013	....	....
Colorado Desert, average of 8 samples	9.91	9.02	.33	....	30.02	32.22	9.59	....	8.91	....

[a] Arizona Experiment Station, 11th Annual Report, p. 156.

[b] Wanting in some of the soils analyzed.

The following table shows the composition of the alkali in a few surface crusts and soils in the Salton Basin. The analyses are some of those given by Means and Holmes.[a]

TABLE 44.—*Theoretical percentage composition of alkali in soil about Imperial, Cal.*

Soils, laboratory No.	Location.	Depth.	Per cent soluble.	$CaSO_4$.	$MgSO_4$.	Na_2SO_4.	K_2SO_4.	$CaCl_2$.	$MgCl_2$.	NaCl.	KCl.	$NaNO_3$.	$NaHCO_3$.
		Inch.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
6308	NE. corner sec. 29, T. 16 S., R. 14 E.	0–½	17.42	9.16	2.62	27.72	2.41	......	......	37.77	......	14.62	5.70
6303	SW. corner sec. 13, T. 17 S., R. 14 E.	0–½	18.36	9.95	......	......	......	17.38	6.23	59.10	0.89	5.19	1.26
6314	NE. corner sec. 36, T. 14 S., R. 14 E.	0–3	15.05	3.97	......	......	......	34.02	6.56	48.76	.85	5.35	.49
6313	NE. corner sec. 29, T. 14 S., R. 14 E.	0–3	15.30	3.69	......	......	......	46.60	8.44	33.08	.86	7.02	.31
6285	NE. corner sec. 29, T. 16 S., R. 14 E.	0–36	.44	27.60	6.33	5.43	......	......	......	12.67	6.78	......	41.19
6286	Subsoil of 6285	36–72	.59	26.26	......	......	......	11.11	9.10	16.15	15.15	......	22.23
6279	NE. corner sec. 21, T. 17 S., R. 14 E.	0–36	.93	32.91	11.18	......	......	......	1.72	29.04	10.96	......	14.19
6298	NE. corner sec. 29, T. 14 S., R. 14 E.	0–36	6.81	14.62	......	......	......	25.89	5.75	42.55	2.34	7.89	.96
6299	Subsoil of 6298	36–72	3.36	29.36	......	......	......	5.29	2.34	56.36	3.67	......	2.98
6295	NE. corner sec. 25, T. 15 S., R. 14 E.	0.36	2.51	3.58	......	......	......	37.21	14.34	39.06	2.55	......	3.26
6296	Subsoil of 6295	36–72	1.82	4.28	......	......	......	15.17	3.40	66.39	5.38	......	5.38

The alkali of the Salton Basin is of the same type ("white alkali") as that of the Sahara Desert in southern Algeria, since in both regions a large excess of gypsum is present in almost all cases, which prevents the formation, under ordinarily good conditions of culture and drainage, of any dangerous amount of the very harmful alkaline carbonates. The Salton Basin samples differ considerably from those from the Sahara in showing rather large percentages of sodium nitrate in the surface crusts, which is entirely lacking in the surface crusts or soils from the Sahara. However, only very small quantities of nitrates occur below the surface crust in the soils of the Salton Basin, unless the soils are so alkaline as to preclude all agriculture. The Salton Basin soils often show considerable percentages of calcium chlorid, wanting in Sahara soils. Salton Basin soils contain much larger percentages of potassium chlorid and sodium bicarbonate and a larger proportion of chlorids and less sulphates than do the Sahara soils examined

The Salton Basin alkali is slightly more dangerous to crops than that of southern Algeria, because of the larger proportion of chlorids, and because of the presence, in many cases, of considerable amounts of sodium bicarbonate, which, if the land is watered excessively and badly drained, may be converted into the very harmful sodium carbonate.

[a] Means and Holmes. Soil Survey around Imperial, Cal. Field Operations of the Bureau of Soils, U. S. Department of Agriculture, Third Report, 1901, p. 601.

FERTILITY OF THE SOILS OF THE SALTON BASIN.

On the other hand, the Salton Basin alkali contains a considerable proportion of useful plant foods, especially sodium nitrate and potassium chlorid, which render the soils very fertile to any plant which, like the date palm, can withstand a considerable percentage of alkali in the soil. The Sahara soils are often mediocre or poor, and date culture suffers in southern Algeria for the want of nitrogenous fertilizers, which are very hard to supply at reasonable prices in such a remote and sparsely settled country. In the Salton Basin it may pay to wash the surface crust down into the soil in order to carry the nitrate of soda down within reach of the roots, in places where it is known that there is little alkali in the subsoil. For instance, if a crust such as No. 6308 of Table 44 (p. 113), containing 2.5 per cent of its weight of nitrate of soda, occurred over such a soil as No. 6285, collected near by, containing only 0.44 per cent of alkali to a depth of 3 feet, it is probable that the crust might be washed down to the level of the roots of the date palm without danger of their suffering from any excess of alkali. Such an operation must, however, always be carried out with caution, and is permissible only when it is known that the soil is relatively free from alkali, and that the amount contained in the crust would not suffice to raise it to the danger point for the date palm in any soil stratum in which the roots ramify.

Considerable amounts of potassium chlorid exist in most of the Salton Basin soils—probably enough to suffice for the needs of vegetation for a long time to come. Besides being naturally so rich, these lands will be improved by the deposition of silt[a] from the Colorado River water used in irrigating and from the addition of the small amounts of nitrates and potash contained in solution. (See p. 106.) In particular the small amount of phosphates the water contains is likely to prove very beneficial to the soils of the basin, naturally poor in this element. Analyses of the Colorado River water made daily for a period of seventeen months show that on the average it carries 13.8 pounds of phosphoric acid in an acre-foot of water or 55.2 pounds in the 4 acre-feet probably needed annually by a date plantation when the trees are full grown. What with the considerable supplies of nitrogen and potash contained in the alkali of these soils and the phosphoric acid brought by the river water, it is probable that the date palm will show a most luxuriant growth and bear heavy crops in the Salton Basin without any fertilizers being needed for many years, at least.

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[a] It must be kept in mind that much of the silt is deposited in the canal before it reaches the land, and in consequence the fertilizing value of the water is not so great as when it leaves the river. (See Means and Holmes, Field Operations of the Bureau of Soils, U. S. Department of Agriculture, Third Report, 1901, p. 598.)

SUBSIDIARY CULTURES TO FOLLOW IN CONNECTION WITH DATE PLANTATIONS ON ALKALINE SOILS.

Although no other profitable crop plant can stand as much alkali as the date palm, there are a number which can endure considerable amounts of alkali and which could be set out on the less alkaline parts of the tract to be planted or under the date palms after much of the excess of salts had been washed out of the soil by several years' irrigation, accompanied by drainage. The grape, the olive, the pomegranate, the jujube, and the fig are commonly grown in the partial shade of the date palm in the Saharan oases. (See Pl. V, fig. 1, and Pl. XII.) All of these plants can endure more alkali than can most fruit trees, though the almond and pear resist considerable amounts. Barley is one of the crops that can stand much alkali, and it is commonly grown in winter between the rows, especially of young date plantations. Sorghum is equally resistant. Asparagus is found to do very well in the salty soils of the Oued Rirh country, and it may prove a profitable minor culture. Cotton is alkali-resistant in Egypt and is grown in the oases in the interior of the Sahara.

Since a species of pistache, which could be used for stock on which to graft the pistache of commerce, occurs in the northern Sahara, where it is the only tree that grows wild, it is not impossible that this choice nut may be grown to advantage on alkaline soils. Carobs can stand the heat and dry air of the desert very well, yielding fruit valuable for horse and cattle food in place of grain, and are at the same time very ornamental evergreen shade trees, suitable for street planting. The Casuarina, the Tamarix, and some of the acacias and Eucalypti are trees well adapted to endure desert climates. Among forage plants the Australian saltbush deserves first mention, for it can endure very large amounts of alkali. Sorghum is another useful forage plant for such land. Saharan alfalfa will prove of great value for the less alkaline soils—those having 0.5 per cent of alkali or less. It is not unreasonable to hope to find a whole series of crops which can endure a considerable amount of alkali in the soil, and which will permit some diversification of agriculture even on the most alkaline tracts that are first put under culture by planting date palms.

LIMITS OF ALKALI RESISTANCE OF THE DATE PALM.

It is naturally of very great importance to determine as nearly as possible the limits of alkali endurance of the date palm, as it is the most profitable crop than can be grown in very alkaline lands, and on large areas in the hotter arid regions of the Southwest it is the only paying crop that can succeed. A careful study of the growth and fruitfulness of the date palm at various points in the Sahara desert shows that although this plant can grow in soils containing from 3 to

4 per cent of their weight of alkali, it does not produce fruit unless its roots reach a stratum of soil where the alkali content is below 1 per cent, and does not yield regular and abundant crops unless there are layers in the soil with less than 0.6 per cent of alkali. The surface soil may, however, be very much more salty, and may even be covered with a thick crust of alkali. It is probable that amounts of alkali below 0.5 per cent of the weight of the soil exert no appreciable injurious influence on the date palm. For example, in a flourishing date plantation at Ourlana, in the Algerian Sahara, at the spot shown in Plate XVII, figure 1 (Ourlana, station No. 2), the surface foot of soil contained no less than 1.52 per cent of alkali and was covered with a crust, while the subsoil at 2½ to 3 feet showed only 0.51 per cent of alkali. The water used to irrigate this soil contained 0.64 per cent of soluble salts, of which 0.40 per cent consisted of injurious alkali. Both in the soil and in the irrigation water the chlorids, very harmful to most plants, predominated; they constituted 80 per cent of the alkali in the surface soil, 40 per cent in the subsoil, and 52 per cent of the dissolved salts in the water. These amounts of alkali of so harmful a character, though sufficient to prevent the culture of any ordinary crop, seemed to be entirely without influence on the growth or yield of the date palm.

If the soil at all depths contains somewhat more than 0.6 per cent of alkali the growth is slower and the yield less than in better land, and where the alkali content is everywhere over 1 per cent date palms do not bear fruit regularly and their growth is very slow. On trees growing in the presence of very large amounts of alkali the leafstalks are usually of a pronounced yellowish color instead of the normal gray green;[a] on such soils in the Sahara the only other vegetation that can exist is a scanty growth of samphires and saltbushes. (See Pl. XV, figs. 1 and 2.)

It must be borne in mind that the percentages given above are for the stratum of soil containing the least amount of alkali and that the surface layers may contain very much more, since the date palm has

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[a] A diseased condition of the date palms called at Fougala, Algeria, "meznoon" (z as in azure), meaning "crazy," occurs rather often among the trees growing on the worst alkali spots and may be caused in some way by the presence of excessive amounts of saline matters in the soil. The leaves of such palms do not unfold properly, but remain dwarfed and distorted, as is shown in Plate XV, figure 2. (This figure shows in the foreground the samphires and saltbushes characteristic of the most alkaline soils.) These meznoon palms are said to be cured in some cases by cutting off all the young leaves and hollowing out the bud, as is done in making "lagmi" or palm wine. When the new leaves push out some months later they are sometimes normal. The Arabs sometimes attempt to cure such trees by tying the youngest leaves into a compact bundle. A somewhat similar disease is described by Masselot (Bul. Direc. Agricult. et Comm., Tunis, vol. 6 (1901), No. 19, p. 134) as occurring in the Tunisian Sahara, where it is called "boussaafa." It attacks principally young palms and by preference the Deglet Noor variety.

the very important peculiarity of being able to withstand large amounts of alkali at the surface of the ground without the crown being injured thereby. Probably this is to be explained by the fact that, like other palms, the date tree has no bark and no delicate cambium layer just beneath; a date palm may be cut all about without dying when an ordinary fruit tree so girdled would perish.

In consequence of the ability of the date palm to endure great accumulations of alkali at the surface of the ground, the "rise of alkali" from the subsoil, so dreaded by growers of other crops, is often not at all dangerous to this plant and may even be advantageous in some conditions, provided thereby the alkali content of the subsoil in which the feeding roots extend is reduced. It is conceivable that in the Salton Basin, California, where, in consequence of the very slight rainfall, the alkali is often very uniformly distributed throughout the soil to great depths, it may prove desirable to draw the alkali to the surface rather than to try to wash it down beyond the reach of the roots at the risk of raising the level of the ground water and suffocating the roots. Once accumulated at the surface, the alkali could be largely removed, as suggested by Professor Hilgard, by scraping together the surface crust and carrying it off the field. The difficulty is that if by judicious irrigation the alkali should be brought to the surface from the subsoil at a depth of, say, 4 to 6 feet, there is always danger that a subsequent irrigation, especially if followed by an exceptionally heavy shower, would bring up alkali from still deeper layers of the subsoil and counteract the beneficial influence of the previous manipulation. The theoretical advantage of bringing about a rise of alkali is shown by the following comparison of a Saharan soil with one from the Salton Basin. In the Salton Basin, at boring 133, about 5 miles north of Imperial (Means and Holmes, Circular 9, Bureau of Soils), the alkali is, as usual in this region, rather evenly distributed throughout the soil. In the Sahara, at Fougala, Algeria (station No. 2), the alkali was largely accumulated at the surface, doubtless in part because of three years' irrigation, but also because the rainfall in this portion of the Sahara Desert is much greater than in the Salton Basin. The following table shows the distribution of the alkali at these two points:

TABLE 45.—*Distribution of alkali at different depths in the Sahara and in the Salton Basin.*

[Alkali expressed in percentage of weight of soil.]

Depth.	Sahara (Fougala, station No. 2).	Salton Basin (boring No. 133, 5 miles north of Imperial).
Surface soil, 1 to 12 inches	1.98	1.02
Subsoil, 12 to 24 inches	.51	.90
Subsoil, 24 to 36 inches (estimated for Fougala)	(.44)	.66
Subsoil, 36 to 48 inches	.38	.61
Average, 1 to 4 feet	.83	.80

Although the total alkali content of the soil to a depth of 4 feet is slightly greater at the Fougala station than at boring 133, the roots of the date palm would reach a layer of subsoil containing only 0.38 per cent of alkali at Fougala, whereas in the Salton Basin station the lowest amount of alkali is 0.61 per cent, or over one-half more than at Fougala. Were the alkali at boring 133 to concentrate at the surface in the same proportion as at Fougala, the lower subsoil would contain something like 0.37 per cent of alkali. However, the soil at 5 and 6 feet in depth at boring 133 contains 0.58 per cent, which alkali content probably continues downward for many feet, so that in order to bring about a diminution of the alkali content at any given depth it is essential that the soil lying deeper is not wetted. Whether such an operation can be carried out in practice is doubtful.

The view outlined above, that the accumulation of alkali at the surface may be beneficial to the date palm in some soils but that such accumulation may be dangerous to the plant if dislocated by unusually heavy rains, is confirmed by the following remarkable observation of Vogel, made at Moorzook in Fezzan, in the interior of the Sahara Desert:

> A heavy rain is considered a great disaster, as it destroys the houses that are built out of mud, and also kills the date palms by dissolving the great quantities of salt which are contained in the soil. For example, about twelve years ago [in 1843?] about 12,000 date palms were destroyed in the vicinity of Moorzook by a rain which lasted seven days.[a]

Moorzook is said to have no regular rainy season, though light showers occur in autumn. There is an abundant supply of underground water near the surface. Rohlfs says: "The palms do not require artificial irrigation [in Fezzan], since the roots seem to reach water everywhere."[b] Date palms are said not to be watered except during the first six months after they are set out. Under these conditions a great accumulation of alkali near the surface is to be expected, and the disastrous result of a heavy rain in washing the alkali down to the level of the roots is not surprising.

This indifference of the date palm to surface accumulations of alkali constitutes one of its greatest advantages over other crop plants for culture on alkaline soils.

RESISTANCE OF THE DATE PALM TO CHLORIDS.

The date palm seems to be resistant to all kinds of alkali, with the possible exception of the soluble carbonates, or black alkali. Common salt and the other chlorids, including the very poisonous magnesium chlorid so injurious to most cultivated plants, are resisted very well

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[a] Vogel, Ed. In Petermann's Geogr. Mitth., 1855, p. 250.

[b] Reise durch Nord-Afrika von Tripoli nach Kuka. In Petermann's Geogr. Mitth., Ergänzungsheft No. 25.

by the date palm which was seen growing at Chegga, Algeria, in a soil containing about 0.8 per cent of chlorids, while amounts of chlorids as great as 0.2 per cent were apparently entirely without effect on the date palm at Ourlana, Algeria.

RESISTANCE OF THE DATE PALM TO SULPHATES.

Sulphates, such as Glauber's salt (sodium sulphate), are still less injurious than chlorids to the date palm, which, when well established, is able to withstand enormous amounts of these salts—probably from 2 to 5 per cent. Roots of the California fan palm, which is probably no more resistant to alkali than the date palm, were found at Palm Springs in the Salton Basin, California (see p. 112), ramifying abundantly in a layer of subsoil 6 feet below the surface, where there was 4.52 per cent of Glauber's salt and 0.26 per cent of magnesium sulphate present. Allowing 0.02 per cent as the amount of gypsum (calcium sulphate) that would go into solution in the soil moisture, the total sulphates would amount here to 4.80 per cent of the weight of the soil. Even greater amounts of sulphates were observed in the surface soil at Chegga, Algeria, where they amounted to 5.11 per cent of the weight of the soil, 4.89 per cent being Glauber's salt; the subsoil here contained 1.82 per cent of sulphates, which represents more nearly what the roots had to withstand, although in addition there was 0.88 per cent of chlorids. It is clear that, like other plants, the date palm can resist sulphates much better than chlorids.

RESISTANCE OF THE DATE PALM TO CARBONATES (BLACK ALKALI).

Whether the date palm can resist the dreaded "black alkali,"[a] the soluble carbonates, is not settled as yet, for none of the soils from the Sahara contained any appreciable amount of these very poisonous salts. At Tempe, Ariz., a soil obtained from the vicinity of the Cooperative Date Garden, where date palms grow luxuriantly, contained some 0.06 per cent of sodium carbonate in the surface foot. Well-drained soils containing an excess of gypsum, such as was observed in all the Saharan samples, can not contain any considerable amounts of soluble carbonates, for if any such salts existed they would immediately react with the gypsum present, and as a result inert calcium carbonate (limestone) and comparatively harmless sodium and potassium sulphates would be formed.

Professor Hilgard has demonstrated the possibility of reclaiming black alkali lands by the application of sufficient amounts of gypsum

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[a] The name "black alkali" is applied because the soluble carbonates change the usually gray desert soils to black, as a result of their action in dissolving the humus. In contrast to black alkali, other soils are called "white alkali," from the color of the surface crusts that form in very alkaline spots.

to decompose the soluble carbonates present in the upper layers of the soil. It is not impossible that the obvious injury which results to the date palm from imperfect drainage may be caused by soluble carbonates, which can form under such conditions, even in the presence of gypsum.[a] It is a matter of much importance to determine the limits of resistance of the date palm to black alkali, as to which it is now impossible to speak with any certainty.[b] Even if the date palm proves to be sensitive to the soluble carbonates it will nevertheless still be possible to engage in date culture on black alkali lands by treating them with gypsum and providing for good drainage.

As yet no data are available for a study of the comparative alkali resistance of the different varieties of the date palm, but doubtless a careful investigation would show that there exists a considerable variation in this important character. Marked differences are known to exist among the diverse sorts of date palms in their ability to endure cold (see footnote, p. 61), and, as shown in the chapter on heat requirements, there are enormous differences in the amounts of heat required to ripen early and late varieties; it is reasonable to expect similar lack of uniformity in their ability to withstand alkali. The great importance of date culture, constituting as it does the only profitable industry that can be followed on very alkaline lands, would warrant a careful search in the date plantations in the most alkaline regions of the Old World deserts, in the hope of securing varieties still more resistant to alkali than those we now possess.

The high degree of alkali resistance of the date palm permits brackish water to be used in irrigating. Commercial date plantations of large extent exist at Ourlana and at Chegga in the Algerian Sahara,

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[a] Color is given to this supposition by the observation of Masselot (Bul. Direc. Agric. et Comm., Tunis, vol. 6 (1901), No. 19, p. 135) that a disease common among young palms, known as "Merd el Ghram," in the Tunisian Sahara, caused by excessive irrigation in badly drained soils, is accompanied by a blackening of the soil about the plant. The palms suffering from this disease cease to grow, sicken, and turn yellow; they may be cured by drainage and by replacing at the same time the blackened soil about the foot of the tree with fresh earth. These symptoms seem to indicate the formation of black alkali, and that it has a very injurious action on the date palm.

[b] It can not be assumed that because the date palm is enormously resistant to white alkali it must necessarily be able to support large amounts of black alkali, for the soluble carbonates have a decidedly alkaline reaction, whereas white alkali, in spite of its misleading name, may be nearly neutral in reaction. It is well known, especially from the interesting experiments of Prof. H. J. Wheeler, of the Rhode Island Experiment Station, that plants differ enormously in their requirements as to soil reaction. Lupines, for instance, are injured by soils having an alkaline reaction, whereas clover, soy beans, and most ordinary crop plants of humid regions are greatly harmed by soils having an acid reaction. It is possible that the date palm is injured by soils having a decidedly alkaline reaction, even if the amount of salts in solution in the soil water be small.

which are irrigated with artesian water containing 0.64 per cent of dissolved salts, and it is said that still more alkaline well water containing 1 per cent of salts is used to irrigate date palms in some of the other oases. Even the brine which seeps through the alkali soils and runs off in the drains is used to water palms growing at lower levels, and in some plantations no other water is available for irrigation (see p. 98). The alkaline water from Lake Elsinore, which proved so very disastrous to the orange orchards about Riverside, Cal., contained only from 84 to 116 grains per gallon, whereas the water used exclusively on the date plantations at Chegga, Algeria, contained 374 grains, and substracting gypsum, 250 grains per gallon of harmful alkali. Water, such as that supplied from Lake Elsinore at its worst, would be adapted perfectly to irrigate date palms. Even the intensely brackish ground water under the Salton Basin, which lies some 50 feet below the surface at Calexico and only about 30 feet below at Imperial, though it contains some 0.4 to 0.6 per cent of dissolved salts, and though it would prove fatal to most crop plants if brought up near the surface by injudicious irrigation, would not necessarily injure the date palm. Many plantations in the Sahara are irrigated with water more alkaline than this. The chief danger to the date palm to be apprehended from a rise of ground water is the suffocation of the roots because of imperfect aeration of the water-logged subsoil.

The immense superiority of the date palm over all ordinary crop plants for culture in alkaline lands becomes evident when it is remembered that all ordinary useful plants, such as wheat, corn, and alfalfa, peach, orange, and prune trees, etc., are killed by as much as 0.5 or 0.6 per cent of alkali in the soil,[a] which amount is entirely without influence on the date palm. The more resistant crop plants, such as barley, sorghum, sugar beets, grapevines, olive trees, and possibly pomegranate, jujube, and pistache trees, are able to withstand from 0.6 to 1 per cent of alkali; but these plants are easily injured by an accumulation of the alkali at the surface, which is perfectly harmless to the date palm. About the only crop plant which can withstand considerably over 1 per cent of alkali is the Australian saltbush (*Atriplex semibaccata*), and even this forage plant can not endure nearly as much alkali as the date palm—probably not half as much. As noted on page 115, asparagus is able to endure much alkali, though the limits of its resistance have not yet been determined. The date palm is, then, the most resistant to alkali of all plants now known capable of commercial culture in arid regions.

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[a] See Means and Holmes, Circular No. 9, Bureau of Soils, U. S. Department of Agriculture, 1902, and other publications of that Bureau.

REGIONS IN THE UNITED STATES WHERE DATE CULTURE CA SUCCEED.

CALIFORNIA.

Salton Basin or Colorado Desert (see Pls. III, IV, XVIII, fig. 1 an fig. 10, p. 102).—It is clear, from what has preceded in this bulleti that the Salton Basin or Colorado Desert is not only the most promi ing region in the United States, or in North America, for the cultu of the best sort of dates, but that it is actually better adapted for th profitable culture than those parts of the Sahara Desert where t best export dates are produced. This favored region, though sma in comparison with the vast arid areas of the Southwest, is neverth less larger than any one Saharan oasis, probably equaling in exte all the oases in the western Sahara from Tripoli to Morocco, and capable of producing all the dates consumed in America. Only the va date plantations along the Valley of the Shat-el-Arab, formed by t junction of the Tigris and Euphrates rivers, near the head of the Pe sian Gulf, which furnish most of the great quantities of dates consume in the United States, are comparable in extent with the irrigable po tion of the Salton Basin.

The study of the life history of the date palm has shown that in t Salton Basin the long, hot summers, the very dry atmosphere, and t almost complete absence of rain during the flowering and ripeni seasons of the date palm render the climate particularly adapted the culture of the choice late-ripening sorts, such as the famous Degl Noor. At the same time the presence of an abundant supply of wat of excellent quality and the extreme fertility of the soil render t conditions unusually propitious for the establishment of this profitab fruit culture. The presence of considerable amounts of alkali in t soil has been shown to be no obstacle to the growth of this plant, whi is harmed only by exceptionally large quantities of alkali. Inde the presence of alkali, by rendering much of the land ill fitted entirely unsuitable for other culture, constitutes one of the most coge reasons for the speedy introduction of this resistant plant in order enable all the lands now under irrigation to be put to profitable use.

Death Valley (see map, Pl. IV).—The Death Valley, a depression some places 320 feet below sea level, situated in east central Californi near the boundary of Nevada, is in many ways very like the Salt Basin, and may be considered as a more northern extension of t same general conditions. Being some 4 degrees (300 miles) farth north than the Salton Basin, the winters are probably much colde and possibly only hardy varieties of date palms will succeed, though is probable that most sorts can be grown in certain protected situ tions if well covered in winter when young. The summer heat

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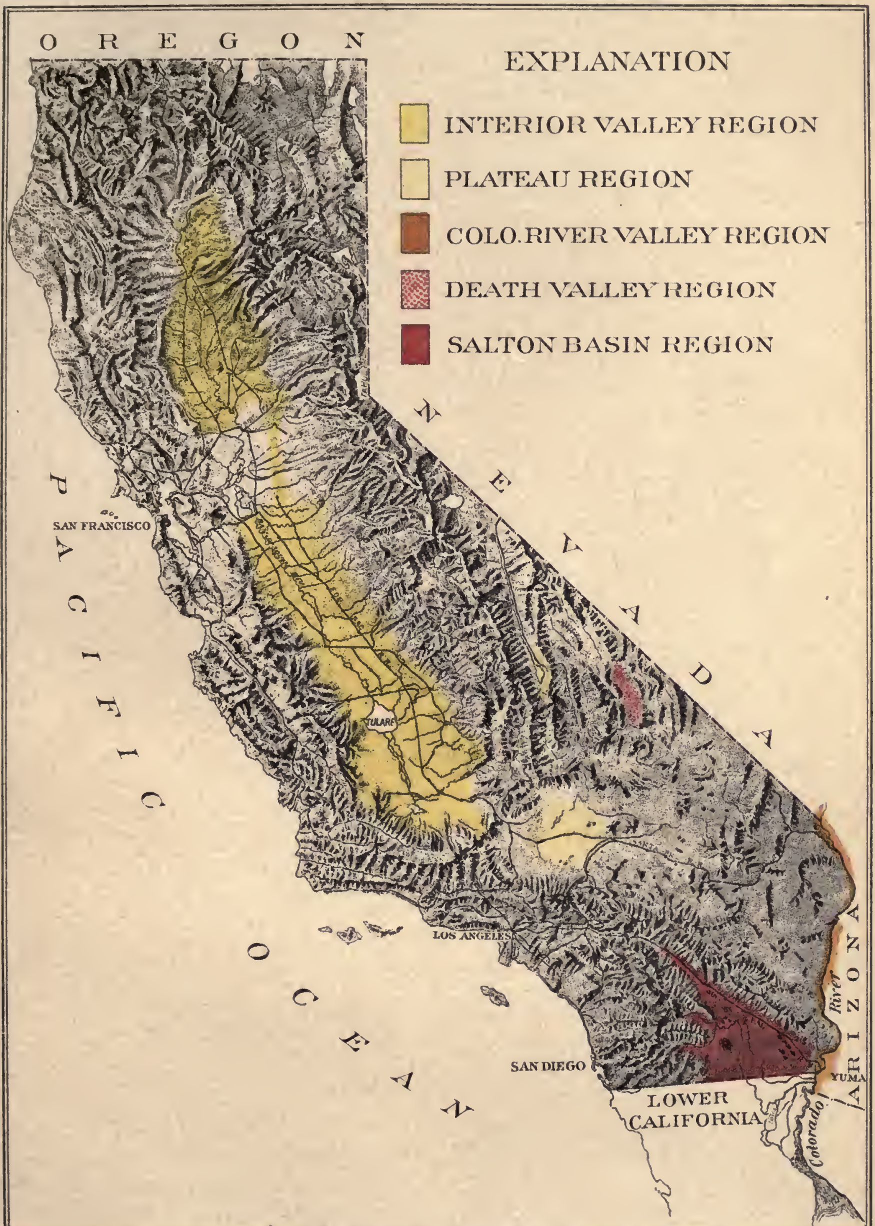
[a] Since the above was written, an experimental date garden has been establish in the Salton Basin at Mecca. (See footnote, p. 110.)



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RELIEF MAP OF CALIFORNIA, SHOWING THE PRINCIPAL REGIONS WHERE DATES CAN BE GROWN.

intense, nearly equaling that of the hottest parts of the Salton Basin; and even very late sorts, such as the Deglet Noor, could mature here perfectly. There is almost no rain, and in consequence no danger of the fruit being spoiled by wet weather during the ripening season in autumn. Unfortunately, there is almost no water available for irrigation in the Death Valley, and no large streams occur in the surrounding country which could be diverted into this desert. It is not known whether artesian water underlies this region, but if flowing wells could be dug it would be desirable to make a thorough test of the Deglet Noor and other first-class late sorts of dates. The date palm is particularly well adapted for culture in such regions remote from railways and from markets, as the crop can be transported to great distances without injury and, being a high-priced dried fruit, represents about the maximum of value, in proportion to the weight and bulk, among agricultural products.

Colorado River Valley (see map, Pl. IV, and fig. 10, p. 102).—This valley, lying partly in California and partly in Arizona, and especially the flood plain, which is irrigated and fertilized naturally by the annual overflow of the river offers considerable promise of being able to produce early drying dates at a cost low enough to enable them to be sold in competition with the so-called Persian dates, which are shipped to our markets in enormous quantities from the region about Bassorah, near the head of the Persian Gulf, and from Maskat, in Arabia. A detailed account of this promising region is given below (p. 129), in treating of the regions suitable for date culture in Arizona.

Plateau region (see map, Pl. IV).—This tableland, comprising the Mohave Desert, separating northern from southern California, would be fairly well adapted for date culture were it not for the fact that the winters are almost everywhere too cold. However, in canyons facing southward, where the cold air can drain off at night to lower levels, the hardier varieties may pass the winters uninjured. From the weather records kept at Keeler and Barstow it would seem probable that the date palm might succeed in the vicinity of these towns. If any attempt is made to grow dates in this part of California attention should be paid to the results of the experiments in date culture made by the California Experiment Station at Tulare, where it was found that irrigation in late summer is very disastrous to the date palm, because it forces a late growth, which is injured during the following winter. However, all through the plateau region the summer heat is insufficient to ripen any but early sorts, and it is very unlikely that date culture will prove a profitable industry in this part of California.

Interior Valley region (see map, Pl. IV).—The largest continuous area in California, and perhaps the largest in the world where dates can be grown, is the interior valley region, comprising the valleys of

the Sacramento and San Joaquin rivers. The climate is here very different from that of the other regions mentioned above, especially in the much heavier rainfall, which in many places is sufficient to permit the date palm to grow without irrigation. As a result of this more humid climate there is more danger of damage to the flowers in spring, and especially more risk of losing the ripening fruit in autumn, in consequence of a spell of wet weather. The summer season is nearly or quite rainless; otherwise date culture would be impossible.

As a result of investigations on the life history of the date palm, it is evident that only the very early sorts can mature their fruit in this region, owing to the insufficient summer heat. These earliest varieties, though often a very palatable fruit, suitable for home consumption, are as a rule unfit for drying and for export. Experiments are now under way in cooperation with the California Experiment Station which will decide in a few years whether any of the early Saharan, Egyptian, and Arabian sorts suitable for drying can mature in this region.

All parts of the San Joaquin and Sacramento River valleys offer about equal advantages for date culture, except in the region where the two rivers unite. This section lies directly east and northeast of San Pablo and Suisun bays, and the cold winds which blow in from the Pacific over San Francisco Bay find their way eastward through this break in the coast range, and thus lower the summer temperature; it is unlikely that any dates can be ripened in this area, which extends from Stockton to Sacramento and across the valley to the foothills.

The winters are mild enough in most parts of the interior valley region to permit date palms to grow without injury, provided they are protected when young. In some of the colder localities only hardy sorts will succeed, and at Tulare it has been found by the California Experiment Station that several of the Egyptian sorts imported in 1889 by the Department of Agriculture are severely injured by freezes in winter, especially if by late irrigation the palms had been kept growing in late summer and autumn (see p. 49). In such cold localities no irrigation should be given after midsummer.

It is interesting to note that the Wolfskill date (fig. 3, p. 31, and Yearbook, 1900, Pl. LXII, fig. 2), which grows at Winters (latitude 38° 32′ north), about in the latitude of Washington, Lisbon, Athens, and Peking, is much farther north than any bearing date palm in the Old World, with the exception of one tree at Nice, France (latitude 43° 45′ north), which is probably not a true date palm but a hybrid between the date palm and the Canary Island palm. There are other date palms still farther north in the Sacramento valley which ripen edible dates, as for instance at Colusa and Willows, at both of which points date palms are growing which occasionally ripen a few fruits.[a]

[a] The Bee, Annual for 1902, p. 3: reported by Mr. J. M. Silvey, of Willows, and W. S. Green, of Colusa.

Indeed, the summer climate at Orland, Corning, Tehama, and Vina, in latitude 40°, seems to be as good as at Winters, and to be only slightly less suitable at Red Bluff or even at Redding, latitude 40° 30′, almost under Mount Shasta. Nowhere else in the world are there any such extensive regions north of latitude 35° where dates can be grown successfully.

Even if dates suitable for drying can not be produced here, it will certainly be possible for settlers all through this region to produce fresh dates for their own tables, and it is quite probable that these fresh dates can be shipped to the principal Pacific coast cities without spoiling.

Coast region of southern California.—Although the winters are never severe enough to injure the date palm and almost no rain falls during summer and early autumn, it is nevertheless very improbable that good dates can be grown in this part of California, for the simple reason that the winds which blow off the ocean are cold and humid and prevent the summer heat from being sufficient to ripen dates for 25 miles or more from the coast. It has been found that the date palm does occasionally ripen fruit at San Diego (see Pl. XX, fig. 1), but the plant is forced entirely out of its normal habits by the very low temperatures which prevail here in spring and summer, and instead of flowering in April, as it does in the Sahara, often does not open its flower clusters until August, in which event the half-grown dates hang on the trees in a green condition all through the winter and ripen only during the following summer. The date palm referred to above, which ripens its fruit at Nice, may be found adapted to the climate of this coast region, but unfortunately this tree has not yet produced any vigorous offshoots and only seedlings are available for testing in California. The best chance of securing dates capable of ripening in this region is by cross fertilizing early varieties with the pollen of the Canary Island palm (*Phoenix canariensis*), which, being adapted to the relatively cool and humid, though nearly rainless, summer climate of these islands, is able to mature its thin-pulped and flavorless fruit all along the California coast, even as far north as San Francisco. It is probable that the palm at Nice is such a hybrid, and that it will be easy for plant breeders, by selecting among numerous hybrids, to find a sort much better than this chance seedling.

NEVADA.

It is probable that the date palm may be fruited successfully in some of the protected valleys in southern Nevada; early sorts are, indeed, almost certain to succeed in the valley of the Colorado River wherever there is any land that can be planted. The actual flood plain, being both higher in altitude and farther north than in California and Arizona,

may prove to be too cold in winter for any but hardy sorts, and, as noted below (p. 132), the annual inundation with cold water will prevent the ripening of any but the earliest sorts. At higher altitude in southern Nevada the summers are hotter, and even midseason or late sorts can be grown if they can withstand the winter cold. For example, at St. Thomas, in the valley of the Virgin River, at an altitude of 1,600 feet, the summers are hotter than at Phoenix, in the Salt River Valley, Arizona, but the winters are colder, the thermometer falling as low as 11° F. in January, 1899—a temperature which is likely to kill young palms and injure old ones. It is not impossible that there may be warm situations in the Pahrump Valley and in Ash Meadows, in southwestern Nevada, though in the absence of meteorological records it is impossible to speak with certainty, and it is probable that the winters are almost everywhere too cold in these valleys to permit dates to be grown. Hardy late sorts of dates would be very desirable for culture in southern Nevada, and it is probable that such could be found in the oases of Persia, where the winter cold is sometimes so severe as to injure or even kill old date palms, although the summer heat is intense. Inasmuch as such sorts would be of great value for culture not only here but also in southwestern Texas and in some parts of California, it would seem advisable to make a thorough search in the Persian oases as soon as possible and to secure the best varieties for trial in America.

ARIZONA.

As has been explained above (p. 61), in treating of the drainage of cold air and the inversion of temperature in relation to date culture, the earlier varieties will probably succeed in some parts of Arizona lying as high as 5,000 feet above sea level, and medium or late sorts in most parts below an altitude of 2,000 feet, except where there is a marked drainage of cold air from some higher level. This area lying below 2,000 feet in altitude would include the whole of southwestern Arizona, with an arm running up the Gila River, and also extending up the Salt and Verde rivers, and another extending along the Colorado river northward, passing up the tributary called Bill Williams River, and reaching as far north in the Grand Canyon as the Hualapai Indian Reservation. This portion of Arizona lying below the 2,000-foot contour line forms on the map the shape of a capital L with a very thick horizontal limb. It must not be supposed, however, that any large part of the 20,000 or more square miles included in the area above limited will ever be planted to date palms or to any other fruit trees, since most of this area is without adequate water to carry on agriculture. The irrigable areas along the Gila River and its tributaries, especially the Salt River Valley, the Upper Gila Valley from Florence westward to the Estrella Mountains, and finally the valley of the lower Gila, especially about Gila Bend, are the localities best

adapted to the culture of the date palm. The whole of the valley of the Colorado, so far as it is irrigable, and especially the flood plain naturally irrigated by seepage from the river and by the annual overflow, is also adapted to the culture of the date palm, but probably only the earlier varieties will succeed. Of the regions just mentioned, only two are now furnished with a sufficient supply of water to render date culture possible on any large scale. These are the Salt River Valley from Mesa westward to Peoria, and the flood plain of the Colorado River. Wherever small amounts of water are available in the other valleys they could be utilized for irrigating date palms, which would undoubtedly succeed, and it is probable that in the future, with increased facilities for irrigation, the upper and lower valleys of the Gila will prove especially suited to this culture.

There is a region in south central Arizona, lying to the south of the Casa Grande ruins, where there are said to be thousands of acres covered with a heavy growth of mesquite trees (*Prosopus velutinus?*) and where water is found at a depth of from 20 to 30 feet below the surface. It is not impossible that if date palms were irrigated in this region when young, they might be able to grow without irrigation after the roots reached moisture. At any rate, both here and elsewhere, where a heavy growth of mesquite occurs and where there are indications of underground water near the surface, it would be desirable to make trial plantations of the date palm.

Salt River Valley.—This fertile region, which is one of the largest of the irrigated valleys in the Southwest, is situated in central Arizona (latitude 33° 25′). Its principal towns are Phoenix, Tempe, and Mesa. As has already been mentioned, the date palms planted by the earlier settlers have been strikingly successful (see Yearbook, 1900, Pl. LVII); in fact, it is no exaggeration to say that there are more bearing date palms producing fruit of good quality in the Salt River Valley than in all the rest of the United States. The Cooperative Date Garden at Tempe (see Pls. XXI and XXII) on June 15, 1902, had on hand (including a few palms at the experiment station farm at Phoenix) 556 trees, belonging to 81 varieties. Besides these 81 imported varieties, there are a number of seedling sorts of merit which have originated in the Salt River Valley, so that in all there are probably nearly 100 distinct varieties of date palms now on trial in this valley.[a] Prof. James W. Toumey, while connected with the University of Arizona, investigated the whole subject of the culture of the date palm in the United States and brought out very clearly in a bulletin[b] published in June, 1898, the fact that in these regions only had the plants imported

[a]Forbes, R. H. Thirteenth Annual Report, Arizona Experiment Station, 1902, p. 244.

[b]Toumey, W. J. The Date Palm, University of Arizona, Arizona Agricultural Experiment Station, Bulletin No. 29, Tucson, Ariz., June, 1898.

by the Department of Agriculture in 1889 and 1890 grown rapidly and produced good fruit abundantly. This bulletin was the first important study of the date palm published in America, and it did much to attract attention to the possibility of establishing date culture as a profitable industry in the Southwest.

Although there are many regions in California, and some in Arizona, where the summer temperatures are higher than they are in the Salt River Valley, the only considerable area of land under irrigation where the climate is more favorable to the date palm is the Salton Basin in California. It may be stated that date culture is no longer an experiment in the Salt River Valley. It is, however, not yet certain that the Deglet Noor variety, which brings the highest price in the market, will come to full maturity here. It is to be hoped that it will, and the outlook is not without promise (see p. 68). If this variety does ripen properly, there can be but little question that it will be profitable to plant it on the best lands in the valley and to irrigate it abundantly. The question as to whether the Deglet Noor can mature its fruits in central Arizona will be settled within a very few years by the experiments now in progress at Tempe, in this valley (see Pl. XXII).

In case the Deglet Noor does not succeed in this valley, the effort should be made to produce a date intermediate in quality between the Deglet Noor and the ordinary dates sold in bulk in this country. Such a good second-class date would compete with the selected Bassorah and Maskat dates for household uses and take the place of Deglet Noor dates to some extent for use as a dessert fruit. Owing to the nearness to markets, the Salt River Valley dates could be sold while still fresh and need not be deformed by the close packing needful to preserve the oriental dates from drying out or from spoiling while en route to America.

The collection of varieties at the Cooperative Date Garden at Tempe is by far the most complete in the world, since it comprises the best known varieties from the Algerian Sahara, from Egypt, and from the regions about Bassorah and Maskat, where most of the dates imported into America are produced, as well as a large collection of varieties from the Pangh Ghur region in Baluchistan. Together with the seedlings that have originated in the valley and the sorts growing at the experiment station farm at Phoenix, there are something over 90 named varieties now on trial in the Salt River Valley. It is very probable that some of these will prove to be adapted for profitable culture in this valley, even if the Deglet Noor can not mature.

There are several seedling dates that have originated in the Salt River Valley in Arizona which promise to be valuable. One of the best of these is the Lount No. 6. It is small, being rather smaller than the Wolfskill date, but of very good texture, of clear amber color when dried, and of fairly good flavor. The Kales date and the Bennet date (fig. 4, p. 32) are seedlings of considerable merit, also growing near

Phoenix, Ariz. In addition, there are several other seedling varieties of considerable value which have already fruited in central Arizona, some of which may prove adapted to culture on a large scale.

Two of the varieties introduced from Egypt by the Department of Agriculture in 1890 have been fruiting for some time at Phoenix, Ariz. In 1900 one of the sorts, the Amreeyah, bore over 300 pounds (see Yearbook, 1900, Pl. LXII, fig. 1), while another, the Seewah, bore over 200 pounds. These dates were packed in half-pound boxes, and Prof. A. J. McClatchie writes that they sold readily for 20 cents a box wholesale and 25 cents retail, and there was a demand in the local market for ten times the quantity that could be furnished. The Seewah in particular is a very promising date for culture in the Salt River Valley, in Professor McClatchie's opinion, as it is fairly early and of excellent quality.

Although a good second-class date could doubtless be grown with profit on the best fruit land, it is probable that this culture will be undertaken first on lands too alkaline to be safe for other crops. Some of the low-lying alkali lands, especially near the date garden at Tempe, have water rising to within a few feet of the surface, which seeps down from the surrounding irrigated fields lying at higher levels. Date palms, when once established, will grow in such situations without any irrigation at all, though they will grow better and yield more fruit if occasionally irrigated from the surface with pure water from the canals.

Colorado River Valley (see fig. 10, p. 102).—The valley of the Colorado River, lying partly in Arizona and partly in California, comprises two adjoining though different situations where the culture of date palms is possible, viz, the flood-plain of the river and the mesa lands lying above the high-water mark not subject to inundation.

The immediate flood-plain is flat and only a few feet (10 to 15) above the low-water mark. It is in some places so narrow as to be only a strip along the bank, while below Yuma and again farther north in the Colorado River Indian Reservation, it is often several miles in width and is covered with a luxuriant growth of willows. The flood-plain is subject to annual inundation from the Colorado River, which overflows its banks every year, like the Nile in Egypt, when the summer heat melts the snows on the high mountains at the headwaters of the river in Colorado and Utah. The retiring flood waters leave a thick deposit of mud, which renders the soil exceedingly fertile.[a]

[a] In 1899 the writer saw a dense growth of 5 to 6 year old willow trees being cut for cord wood. The trees were 25 to 35 feet in height and from 6 to 10 inches in diameter near the ground. Any possible doubts as to the accuracy of the determination of the age of these trees, which was made by counting the annual rings of growth, were dispelled by the evidence of a woodman, who asserted that some five years before all trees of any considerable size had been cut from this tract of land.

The position of the larger bodies of easily irrigable land lying along the Colorado River is shown in fig. 10, p. 102. The cross-hatched areas in this figure along the river indicate low-lying lands, and are more extensive than the flood-plain proper, although in very high flood most of the areas marked on the map would be overflowed. All these lands are easily irrigable without expensive diversion works, which would be necessary were the water to be conducted to the mesas overlooking the Colorado. The land comprised in these areas amounts to some 800 square miles,[a] distributed as follows:

	Square miles.
Cottonwood Valley in Nevada and Arizona	14
Mohave Valley in Nevada, California, and Arizona	160
The small valleys near the junction of the Bill Williams River	56
The great Colorado Valley in California and Arizona	382
The valley in California and Arizona just above the junction of the Gila River at Yuma	80
The valley on the right bank of the river below Yuma in Arizona	108

There is a large area of similar land in Mexico along the Colorado River, as may be seen from the sketch map, fig. 10, p. 102.

Recent detailed surveys made by the Hydrographic Office of the Geological Survey[b] show that there are between 400,000 and 500,000 acres of irrigable land in the valley of the Colorado River between Fort Mohave and Yuma, and there are in addition large areas of land in Arizona below Yuma already irrigated, while still more can be put under water at slight expense. The flood-plain proper, naturally irrigated by the annual overflow of the river, does not comprise so extensive an area, but nevertheless embraces several hundred square miles of the very richest of these exuberantly fertile alluvial soils.

Of the 100 square miles (63,469 acres) surveyed in 1902 in the Colorado River Valley south of Yuma, Ariz., Holmes says: "About 75 per cent of the lands of the valley are overflowed and a layer of sediment added to the soil each year. The deposition has been much greater near the present stream bed than farther back, so that the lands immediately bordering the stream are higher and covered by only a few inches of water during the flood season, while those farther back may in places stand under 7 or 8 feet of water."[c]

The land near the river is usually nearly free from alkali, which occurs chiefly "just above the high-water line of present overflow, where evaporation from the surface has taken place without any surface flooding, showing plainly that the alkali is the result of the

[a] An estimate of 700 square miles is made by Whipple, Pac. Ry. Rept., vol. 3, Pt. I, pp. 40–41, to include the lands from Fort Mohave to Yuma.

[b] Lippencott, J. B., and Davis, Arthur P. Colorado River Division in Arid Land Reclamation Service, First Annual Report, 1903, pp. 106–125.

[c] Holmes, J. Garnett. Soil Survey of the Yuma Area, Arizona. In Field Operations of the Bureau of Soils, Fourth Report, 1902, p. 781.

evaporation of the river water. Other alkali areas are found along the foot of the bluff, being caused by a small amount of seepage from the high lands above."[a]

In regard to the control of the overflow water, which is the problem of first importance in all ordinary agriculture, Holmes says: "Until this water is effectually in hand no farming worthy of the name can be done. To control the overflow it will be necessary to construct a dike or levee along the river, to connect with the mesa land below, of such height and strength as to keep out the river. As has been previously stated, the ground water of the valley rises and falls with the river, and some places are now overflowed 6 to 8 feet. The confining of the river would cause it to rise higher in the channel, so that the ground water over the present overflowed part of the valley would have several feet of head, thus bringing it near to or above the surface. This would necessitate the installation of a drainage system, with a pumping plant at the lower end of the valley to lift the water above the levee and back into the river. This leveeing and draining would be expensive, but since the subsoil is usually quite porous the drains need not be close together, and the natural fertility of the soil, together with the advantages of abundant water and almost tropical climate, would certainly make such reclamation a paying investment."[b]

If it is found, as now seems probable, that the date palm can be grown on the lands subject to overflow without artificial irrigation and without any such expensive system of levees and of drainage by pumping, then it will doubtless be possible to grow dates here as cheaply as in the Bassorah region, where likewise no hand labor is necessary to carry out irrigation when once the canals have been dug.[c]

The luxuriant growth and abundant fruiting of the seedling date palms (Pl. XX, fig. 2) grown by Mr. Hall Hanlon in the flood-plain some miles west of Yuma, on the California side, show that, in some places at least, the seepage from the river, which goes on throughout the year, and the thorough soaking which the land receives at the time of the annual overflow, render irrigation unnecessary. The deposit of mud left by the flood waters suffices to maintain the fertility of the soil and renders any manuring superfluous.

Although the meteorological records kept for several decades at Yuma, Ariz., on the banks of the Colorado River, show the summer climate to be nearly as hot as at Phoenix, in the Salt River Valley (though much cooler than in the Salton Basin), the dates planted by Mr. Hanlon usually fail to mature and must be ripened artificially. As was mentioned above, on page 50, this failure to mature the fruit

[a] Holmes, J. Garnett, Soil Survery of the Yuma Area, Arizona, 1902, p. 786.

[b] Holmes, J. Garnett, l. c., p. 791.

[c] Fairchild, D. G. Bulletin 54, Bureau of Plant Industry, U. S. Department of Agriculture, p. 15.

is probably due in part at least to the lowering of the temperature of the soil about the roots[a] and of the air about the leaves by the overflow of cold water from the melting snows of the Rocky Mountains. This annual flood occurs in the midst of the hot season, usually early in June, and the waters remain on the land for several weeks.

Early sorts of dates, such as the Rhars and Teddala, undoubtedly will succeed in this favored region, which has many advantages for this culture. The land is irrigated and fertilized naturally, the dry air favors the ripening of fruit of a good quality, the very low rainfall in spring and autumn permits the date palm to flower and ripen its fruit unhindered by bad weather, and the winters are so mild that no injury by cold is to be apprehended after the young palms have once taken root.

The date palm has a great advantage over other fruit trees for culture in the flood plain, in that, when once established, it can resist the erosive force of the flood waters without being injured or losing its crop of fruit. There are thousands of acres of this land in California and Arizona now lying waste which could be utilized for this profitable culture if a variety of date palm could be found which produces early ripening fruit fit for drying, and which is adapted to the soil and climatic conditions of this region. Indeed, the chance to secure exuberantly fertile lands, requiring no irrigation, at low prices, gives this flood-plain great economic advantages over other regions for the production of an ordinary or second-class date, such as those that are now imported into this country in enormous quantities from the somewhat similar region about Bassorah, in the valley of the Shat-el-Arab at the head of the Persian Gulf, and from Maskat. No fewer than 9,000 tons of these dates were imported in 1901, so the market is practically unlimited, provided the cost of production can be kept down to a point permitting competition with the oriental dates. The date producer in the Colorado River Valley would have the great advantage over his Bassorah rivals of enormously greater proximity, both in distance and in time, to the great markets in the interior of the United States.

The prospect for successful culture in this region of the ordinary dried dates, one of the staples of the fruit trade, is so good as to warrant making a careful search in the Old World date countries for suitable sorts to grow here. Fortunately, the Department of Agriculture has already secured and has growing in the Cooperative Date Garden at Tempe, Ariz., many of the early-maturing sorts of dates from the Algerian Sahara, as well as from the valley of the Nile in Egypt and the valley of the Shat-el-Arab at Bassorah, the two latter regions having climatic and soil conditions somewhat resembling those

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[a] As shown on p. 49, warm irrigation water is very advantageous in date culture. Doubtless the date palm is as sensitive to the soil temperature as to the air temperature.

of the Colorado River Valley. In addition, the varieties from the island of Djerba, off the coast of Tunis, where only early sorts can mature, as well as the many early kinds reported from the Tunisian Sahara, should be secured for trial. Possibly other sorts of value could be found among the multitudes of seedling date palms growing in the valleys of the Indus and its tributaries in the Punjab, in India.

On the higher lands along the valley of the Colorado the conditions are very different from those described above, for, lying above the flood-plain, these lands are not subject to annual overflow and consequently there is no lowering of the summer temperature by the cold flood waters. The meteorological records kept at Yuma, Ariz., near the Mexican boundary, and at Needles, Cal., near the Nevada boundary, indicate that midseason and even late sorts, including possibly the Deglet Noor, may be expected to mature fully in this region.[a] So there is a good prospect for successful date culture wherever it is possible to irrigate the land.

NEW MEXICO.

All of New Mexico is over 2,500 feet above the sea level, and nine-tenths of its area is above 4,000 feet in altitude. In consequence the winters are almost everywhere too cold to permit the culture of any but hardy sorts of the date palm, and the summer heat is inadequate to ripen any but the earliest varieties. The winters are much too cold for the date palm in the principal irrigated regions, the valleys of the Rio Grande and the Pecos rivers, where this plant would be very useful for planting on alkali lands. From a study of the meteorological records, it would seem that La Paz, at 4,836 feet altitude, in south central New Mexico, near the Sacramento Mountains, has the most promising climate for date culture. The next best climatic region is found in the valleys of the Gila and Rio Mimbres, in the southwestern corner of the Territory. This latter region is of considerable extent, but unfortunately the winters are usually so cold that young palms would be injured if not protected. During the cold wave of 1899 the temperature fell below 7° F. at all the stations where records are kept, except at Gage, altitude 4,480 feet, where the record shows a minimum temperature of only 16° F.

Very early sorts of date palms capable of withstanding much cold are needed for trial in New Mexico. Such sorts are most likely to be found in the oases of Persia, especially in those which from their high altitude or northern position have a very cold winter climate. The northern Sahara, though it contains early varieties suitable for culture in the interior valley region in California and in the Colorado River

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[a] Prof. R. H. Forbes is strongly of the opinion that the Deglet Noor date will ripen in the Colorado River Valley about Mellen and Fort Mohave, Ariz., where the climate is exceptionally hot. (Letter to the author, dated Tucson, March 1, 1904.)

flood plain, where the winters are comparatively mild, is unlikely to yield sorts suitable for New Mexico or for the plateau region of California, where hardiness is indispensable, for the reason that in the northern Sahara, even in oases lying at high altitudes, the winter climate is comparatively mild and equable.

TEXAS.

Only the extreme southwestern part of Texas, bordering the Rio Grande from the mouth of the Pecos River to near Brownsville, is adapted to the culture of the date palm. Throughout the eastern half of the State and in a strip along the Gulf coast, down to the Mexican boundary, the climate is too humid and the summers are too cool to ripen the fruit properly, while in all the northern part of the State, above San Antonio (latitude 30° north), the winters are too cold to permit the date palm to grow out of doors without protection. In the region lying south and west of San Antonio, between the humid Gulf coast and the Rio Grande, the summers are hot enough to mature even the medium or late varieties of dates. Fort McIntosh, in Webb County, at 460 feet altitude, has a summer temperature somewhat higher for the months from May to September, inclusive, than at Phoenix, Ariz. The rainfall averages in this region only about 10 inches, and the late summer is usually dry enough to permit dates to ripen; irrigation would usually be necessary. Ordinarily the winters are not severe enough to injure the date palm if protected when young, though this part of the State is occasionally exposed to "northers," during which the temperature sometimes falls very low. In February, 1899, for example, it fell to 7° F. or below all over the region where the date could be grown, and this temperature would doubtless injure or kill even old date palms. Such low temperatures are, however, very exceptional, and the date should be tested in this part of Texas wherever water can be obtained for irrigation.

Midseason and late varieties, resistant to winter cold, which are needed here and in southern Nevada, are most likely to be found in the depressions in the Persian plateau, where the summer heat is intense and, at the same time, the winters are rigorous. There is much less chance of finding hardy sorts in the Sahara, where the winters are mild, especially in low altitudes, where alone there is sufficient summer heat to ripen late varieties.

NO DANGER FROM MEXICAN COMPETITION IN DATE CULTURE.

The date palm was introduced into Mexico soon after the conquest, probably by means of seeds brought from Spain by the missionaries. Some of the palms in Sonora and Lower California are very old and have reached great height. A group of such old trees is shown in the frontispiece. They were growing at Hermosillo, only 150 miles south

of the United States boundary, where the climate is not very unlike that of the hot valleys of Arizona. There are extensive date plantations in Lower California, especially in the central part of the peninsula, and considerable quantities of dates, packed in rawhide bags, are shipped from here to the cities of Mexico, and some even as far as Arizona and California. According to the statistics published by the Mexican Government, Lower California produced 137,300 kilograms (about 300,000 pounds) of dates in 1897, worth 10,845 Mexican dollars. In 1898 the production amounted only to 32,485 kilograms.

It might be supposed that northwestern Mexico would be better adapted for growing dates than the Southwestern States, since date culture in Sonora and Lower California has long ago passed the experimental stage and is a well-established industry. Furthermore, in these regions there is no danger of young palms being injured by winter cold, while from the latitude, some 5 degrees south of the Salton Basin, the summer heat might be expected to exceed that of the hottest deserts of California and Arizona. As a matter of fact, however, the absence of high mountain ranges and the proximity to the Pacific Ocean and to the Gulf of California permit the sea winds to sweep more or less freely over this whole region, thereby so reducing the temperature and increasing the humidity that late sorts of dates almost everywhere fail to mature on the tree and must be ripened artificially.[a]

Nowhere in Mexico is there any region comparable to the Salton Basin, in California, a depression below the sea level, surrounded on two sides by high mountain ranges which form an effective barrier to the cold, humid winds from the ocean.[b] Adding to these climatic advantages, the abundance and cheapness of the water supply, and the greater proximity to markets, it becomes evident that American growers of first-class dates have no need to fear Mexican competition. Even the growers of second-class and ordinary dates have little cause for alarm, for everywhere in Mexico date culture is carried on in the most primitive manner, seedlings being everywhere grown and the propagation of superior varieties by offshoots nearly or quite unknown. At present the inferior and badly packed seedling dates produced in Mexico are the poorest that reach our markets, and are of no importance whatever.

[a] By exposure to the sun during the hot part of the day and storing indoors wrapped up in blankets at night. (Observations of Prof. R. H. Forbes in Lower California, communicated verbally to the writer, 1902. See p. 29.)

[b] Except possibly Maquata Basin, a region below sea level around the Laguna Maquata (see fig. 10, p. 102), in Lower California, just south of the boundary line, which may some day rival the Salton Basin as a date-producing region, as it can be irrigated from the Hardy River and is protected by mountain ranges on nearly all sides. It would be very desirable to explore more fully this interesting region, which, though adjoining our boundary, is one of the least known areas in North America.

In view of the great number of seedling dates that occur in Lower California and Sonora, it is probable that there are among them some valuable sorts which should be found and introduced into Arizona for trial. Unfortunately the older trees, whose value is best known, have long ago ceased to produce offshoots, so that such sorts can not be propagated.

PROFITS OF DATE CULTURE.

Wherever the Deglet Noor and other choice late varieties of dates can be grown date culture will be exceedingly profitable. In a region like the Salton Basin, California, where the winters are never cold enough to harm seriously old date palms, where the spring and autumn seasons are practically rainless, preventing injury to the flowers or to the ripening fruits, and, above all, where the summers are always hot enough to insure the perfect ripening of the fruit, the certainty of a crop is almost absolute, especially as the land is very fertile and the irrigation water of good quality.

The average yield of a Deglet Noor date palm is variously put at from 88 to 132 pounds. Counting only 75 pounds to a tree, the yield per acre would be 4,500 pounds if the trees were planted at the usual distance of 26⅔ feet. Such dates, even of the second grade, sell on our markets at from 35 to 50 cents a pound at retail when packed in fancy boxes, and would bring probably one-quarter as much in bulk at wholesale, or from 8 to 12 cents a pound, especially as they would ripen in the Salton Basin early enough for the Holiday markets. Allowing 10 per cent for loss in packing, there would still be 4,000 pounds of dates to the acre. Of this crop about 1,000 pounds would be of the first grade (see p. 35), worth, say, 10 cents a pound at wholesale; 1,300 pounds would be second grade, such as now reach our markets packed in three-quarter pound paper boxes, worth about 8½ cents a pound, and the remaining 1,700 pounds would be third-class dates, to be sold in bulk at, say, 2½ cents a pound, or in all some $250 worth from one acre. The care required by the date palm is much less than that necessary for any other fruit tree, and the fruit cures naturally on the tree and can be gathered quickly and easily by cutting off a whole bunch at a time. It is probable, therefore, that $100 per acre would cover all the fixed expenses of an orchard of Deglet Noor palms in full bearing, leaving a profit of some $150 per acre.

Offshoots bear fair crops of fruit from three to five years[a] after being planted, which is but little, if any, longer than many other fruit trees, such as the orange, fig, pear, etc., require to reach fruiting age. The date palm comes into full bearing from eight to twelve years after being planted, and lives to a much greater age than any other fruit

[a] A proof of the ability of a date offshoot to fruit abundantly at an early age is afforded by the Deglet Noor offshoot shown in Plate XXII, which was set out at Tempe, Ariz., in July, 1900, and which when photographed in August, 1903, just three years and one month later, bore three fair-sized bunches of fruit.

tree, bearing profitable crops even when a century or more old. No expensive pruning is required by this fruit tree, and it is remarkably free from diseases and injurious insect pests. The amount of labor required in a date plantation is very much less than for most other fruit culture, and this constitutes a great advantage in its culture, especially in desert regions, where labor is scarce and high priced. The fruit does not ripen suddenly and need immediate care, but may often be left on the tree for a week or two after it matures without being injured.

It would be difficult to imagine a fruit better adapted for growing in the Salton Basin than the choice late varieties of the date, and at the same time a culture better suited to the needs of the country.

Although not offering promise of being so unusually lucrative as the culture of the Deglet Noor dates, the production of good second-class dates, comparable with the best grades of so-called Persian dates, may nevertheless prove to be a paying industry, yielding profits equal to those given by other fruit cultures. The Salt River Valley in Arizona, which may be warm enough to permit the culture of even the Deglet Noor dates, can certainly produce the best grade of second-class dates, suitable for household use and serving as a substitute for Deglet Noor dates for dessert fruit or for use in confectionery. The American growers will have the great advantage over their rivals in the Persian Gulf region of much greater proximity to the centers of consumption, which will enable them to put their crop on the market earlier in the season and in fresher condition.[a]

Even the growing of ordinary dates, like those sold in bulk at the fruit stands, may prove a paying culture if carried on on an extensive scale where land and irrigation water are cheap. Being packed tightly together in boxes holding a hundred pounds or so, the labor of preparing them for market is much less than for the finer dates, which must be arranged carefully in small boxes to prevent the fruit from being crushed or deformed by mutual pressure. The flood-plain of the Colorado River in California and Arizona, where land that is naturally irrigated and fertilized by the annual overflow of the river can be had cheaply, offers promise of being suited for the profitable culture of such ordinary dates.

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[a] Another great advantage of American-grown dates will be their superior cleanliness. Fairchild says (Persian Gulf Dates, p. 29), in regard to the ordinary Persian dates of our fruit stands, "the stories which one hears in the region of the conditions in the packing sheds and the personal uncleanliness of the men, women, and children who put up the dates are enough to disgust a sensitive person and to prevent his ever eating packed dates again without having them washed. No old inhabitant thinks of eating a date without first thoroughly washing it in a glass of water, unless the cook has prepared it beforehand, and the sale of dates in America might fall off decidedly were it generally known how intimately the unwashed hands, bodies, and teeth of the notably filthy Arabs often come in contact with the dates which are sold by every confectioner."

EXTENT OF THE MARKET.

The enormous quantities of dates imported into this country every year are a measure of the extent of the market for the cheaper grades of this fruit. The average value of the imports of dates was $402,762 per annum for the ten years ended June 30, 1900, and the following table gives the quantities and values of imports during the last five years, almost entirely from Bassorah and Maskat:

TABLE 46.—*Quantities and values of dates imported into the United States.*[1]

Year ended June 30—	Quantity.	Value.
	Pounds.	*Dollars.*
1897	11,847,279	284,056
1898	13,561,434	371,992
1899	12,943,305	324,087
1900	19,902,512	410,349
1901	18,434,917	372,400

[1] Yearbook, Department of Agriculture, 1901.

The value per pound is very low for these common dates, amounting to 2.06 cents in 1900 and 2.02 cents in 1901. These values are those invoiced at the port of export, and the dates probably sell at wholesale for at least 50 per cent more at the receiving port.[a]

Even at these prices it is probable that date culture would be profitable if varieties that yield abundantly and regularly were planted on rich, naturally irrigated lands, and it is evident that the market is practically unlimited if the cost of production can be kept low enough to permit competition with the oriental dates.

There exists already a large market for a date of superior quality, suitable for household uses and for employment in confectionery, while the demand for the finest grades of Saharan Deglet Noor dates far exceeds the supply even when they are sold for more than selected Smyrna figs. American orders for a quarter of a million pounds have been refused by the Algerian producers because the supply barely suffices for the European demand. The consumption of these delicious dates is certain to increase as their merits become better known; they reach the same class of consumers as Smyrna figs, and like them can be served as a dessert fruit which can be eaten without soiling the fingers. At somewhat lower prices a practically unlimited market would exist for Deglet Noor dates, and the American grower would have the great advantage over his rivals in the Sahara of being able to gather the crop in abundant time for the Holiday trade.

[a] Thus Mr. E. W. Maslin shows that while the average invoiced value of figs imported into the United States is 5.7 cents a pound, the prices brought by these figs at auction sales in New York City range from 9 to 28 or 30 cents a pound. (See Eisen, G., The Fig, Bulletin 9, Division of Pomology, U. S. Dept. of Agriculture, p. 289.)

IMPORTANCE OF LIFE HISTORY INVESTIGATIONS IN DEMONSTRATING THE FEASIBILITY OF DATE CULTURE.

The importance of a detailed study of the climatic and soil requirements of the date palm is clearly shown in treating of the regions in the United States adapted to its culture, as well as in the discussion of the heat requirements and of the alkali resistance of this remarkable plant. No other crop plant can withstand so much alkali in the soil or in the irrigation water, and tens of thousands of acres of alkali lands in the irrigated areas in the Southwest can be reclaimed and put to profit only by growing dates. This renders it of the greatest importance to determine the extreme geographical limits of the regions where dates can be produced with profit in order that this invaluable plant may be utilized on alkali lands wherever possible.

Not only is it possible as a result of life history investigations to indicate with some degree of precision the regions where dates can be grown, but also to predict the types of varieties which alone can succeed in each region, and further, to indicate in which of the date-growing countries of the Old World such types can most likely be secured. For example, in order to secure hardy late-ripening sorts able to withstand the winter cold in Texas and southern Nevada, search should be made in the oases of central Persia, near the northern limit of date culture, where the winters are so severe that even old, bearing palms are sometimes killed, but where the summers are nevertheless very hot. North Africa on the contrary, is the least promising region to search for such sorts because of the mildness and equability of the winter climate, even in the oases situated on the slopes of the Atlas Mountains limiting the Sahara to the north. On the other hand, early maturing sorts, suitable for culture in the interior valley region of California and in the flood-plain of the Colorado River in Arizona and California, where the winters are relatively mild and the summer heat deficient, are most likely to be secured in just these oases on the slopes of the Atlas Mountains, though such varieties may be expected to occur in oases at high altitudes in the interior of the Sahara and in Arabia. Choice late sorts of date palms, suitable for culture in the hotter valleys of Arizona and in the Salton Basin, California, are most likely to be found in the oases at low altitudes in the interior of the deserts of Sahara, Arabia, and Persia.

It is also possible, from a study of the life-history factors of the date palm, to warn intending planters against attempting its culture in regions where it can not succeed. Thus it becomes possible to establish a new fruit industry in a rational manner without having to await the tardy results of costly and often badly conducted trials made without adequate foreknowledge of the requirements of the plant. Such trials often lead to elusive hopes on the one hand and to unjust

condemnations on the other. To attempt to produce dates in Florida or in the coast region of California because the date palm grows well there, would be to commit a capital error, for no marketable dates can be produced in climates so humid as that of Florida or so cool as that of the California coast. To try to grow drying dates of the ordinary mid-season or late sorts in the interior valley region of California because the Wolfskill date palm at Winters produces every year a good crop of palatable dates would be an error almost as disastrous, because only very early sorts, for the most part unsuited for drying or for export, can be matured in this region.

It is confidently to be expected that in a few years this new branch of biologic and economic science which concerns itself with the determination of the exact requirements of crop plants as to climate and soil, and with the finding of the limits of their powers to resist unfavorable influences such as cold, excessive heat, drought, alkali, violent winds, etc., along with a study of the cultural requirements and market conditions of the new industry, will become so well known and its value so well recognized that it will become a comparatively easy matter to enlist the necessary capital and skill in a new culture when once detailed life history investigations have furnished a sound basis for judgment as to the chances of its proving a financial success in any given region. After such studies have been made, or during their progress, a few carefully planned demonstrations in suitable localities conducted by the Department of Agriculture, the State experiment stations, or in cooperation with skillful planters will take the place of haphazard testing by experimenters, and of the usually indecisive and often enormously expensive trials by private growers.

Millions of dollars have been thrown away in attempts to grow crop plants in regions where a properly carried out life history investigation would have shown that there was no hope of success. Unfounded inflation of values of agricultural lands, and the rush into new cultures in unsuitable regions by whole communities at a time as the result of a "boom," could largely be avoided were it possible to furnish the would-be planter with a black-and-white statement of the necessities of the crop plants under discussion, whereby he would be able to question intelligently whether the region were adapted to the proposed cultures.

At present it is no exaggeration to state that the life history requirements and the limits of the power to resist unfavorable environmental conditions are far better known for many microscopic lower plants, such as bacteria, fungi, and algae, even for species having no economic importance, than for the most important crop plants whose culture provides employment for tens of millions, and whose products constitute the daily food of hundreds of millions of human beings. Such a condition is discreditable alike to biological and to agricultural science and should not longer continue.

SUMMARY.

The date palm can endure any degree of heat and any amount of dryness in the air, and is even favored by hot winds and by a rainless summer. The best sorts can mature only in regions having a very long and very hot growing season.

It can endure more alkali in the soil than any other profitable crop plant and can thrive on soils containing from 0.5 to 1 per cent of alkali, even when irrigated with brackish water containing 0.43 per cent (430 parts per 100,000) or more of injurious alkali. It can withstand without injury accumulations of alkali at the surface of the soil that would kill all other crop plants, even those considered to be very resistant to alkali.

The choicest date that reaches America and Europe, the famous Deglet Noor of the Algerian and Tunisian Sahara, is very sweet, of exquisite flavor, and is adapted to serve as a dessert fruit; it sells for more than Smyrna figs, being the most expensive dried fruit on our markets. The demand for these dates during the holidays is nevertheless greater than the supply, and if they could be sold somewhat cheaper the consumption of this fruit would be enormous.

The Salton Basin or Colorado Desert, in southeastern California, recently put under irrigation, has a hotter and drier summer climate than the Algerian and Tunisian Sahara, where the best grades of Deglet Noor dates are grown, and is, indeed, better adapted to the culture of this fruit, since not only is the climate more favorable but the soils are richer and the irrigation water is of better quality.

The date palm will prove of equal value on the more alkaline areas of other arid regions in the Southwestern States where the winters are warm enough to permit it to grow. Most regions do not have sufficient summer heat to mature the Deglet Noor date, and other sorts which ripen earlier must be planted.

It is very probable that the culture of the best second-class dates, suitable for employment in confectionery and for household uses, will prove a profitable industry in the Salt River Valley, Arizona, and it is possible that the Deglet Noor variety may mature there.

Even the growing of ordinary sorts, such as the oriental dates, which are imported into this country in enormous quantities, may pay in some favored regions, such as the flood-plain of the Colorado River in Arizona and California, where exuberantly fertile lands can be had cheaply, and where the annual overflow and seepage from the river render artificial irrigation unnecessary.

Although date palms are likely to be grown first on soils too alkaline for other crops, the culture of the finer sorts promises to be a most profitable fruit industry that would warrant planting on the very best lands and the employment of the most modern horticultural methods.

DESCRIPTION OF PLATES.

PLATE I. Old date palms at Hermosillo, northern Mexico. Orange trees, peppers, and alfalfa are growing under the palms. December, 1899. Negative by the author.

PLATE II. Map of a portion of the Sahara Desert, in southern Algeria, showing the principal centers of date culture, Zibane, Oued Rirh, Oued Souf, etc. Reduced from 1 : 800,000 map of Service géographique de l'Armée, Paris. Scale 1 : 2,400,000. Localities where soil samples were secured are marked with a star. The fine lines indicate caravan routes. The railway does not yet extend beyond Biskra.

PLATE III. Map showing distribution of soil types and of alkali in the Imperial area in the Salton Basin, California. Prepared by the Bureau of Soils, U. S. Department of Agriculture, in 1903.

PLATE IV. Relief map of California, showing the principal regions where dates can be grown. Reduced from a drawing made after a photograph (furnished by Prof. Alexander G. McAdie) of a relief map of California exhibited at the World's Columbian Exposition, Chicago, 1893.

PLATE V. Fig. 1.—Date garden in Old Biskra, Algeria. Bunches of nearly ripe fruit are seen on the taller palms; fig trees are growing underneath in the partial shade. August, 1902. Negative by Thos. H. Kearney and Thos. H. Means. Fig. 2.—Date palms at Old Biskra, Algeria. To left, two old male date palms, showing more abundant leaves and thicker trunks than the female trees beyond. Negative by the author.

PLATE VI. Fig. 1.—Native gardeners (Rouara) at Ourlana, Algeria, putting date offshoots into sacks, preparatory to shipment by camel back; to the right is seen the corner of the date plantation. Soil samples (Ourlana, Station No. 1) were obtained a few rods from here, May, 1900. Negative by Charles Trabut. Fig. 2.—Caravan loaded with date palm offshoots for the Tempe garden, Arizona, starting from Ourlana northward toward Biskra, Algeria, May, 1900; negative by Charles Trabut. Fig. 3.—Final trimming of date offshoots at Algiers, preparatory to packing for shipment to America, June, 1900. Negative by the author.

PLATE VII. Fig. 1.—Flower cluster of male date palm just emerged from sheath; flowers opening and letting pollen escape. (One-fifth natural size.) Fig. 2.—Three female flower clusters. To left, just opening, ready to pollinate; in center, pollinated, male twig tied fast; to right, ten days after pollination. (One-fifth natural size.) Fig. 3.—Male and female flowers of the date palm, magnified: Above, young fruits turning green a week or so after pollination; in middle, female flowers ready to be pollinated; below, male flowers just shedding pollen. (Three times natural size.) Negatives by the author.

PLATE VIII. Fig. 1.—Forest of old date palms at Biskra, Algeria; an Arab has climbed the tallest tree (in the background), and is pollinating the flowers, May, 1900. Negative by the author. Fig. 2.—Arab pollinating a date palm, Ramley, Egypt, March 24, 1901; a rope passed around the trunk and attached to a broad belt at the waist aids in climbing. Negative by D. G. Fairchild. Fig. 3.—Arabs demonstrating the operation of pollinating the date palm; the cluster of female flowers is partly removed from the sheath and a sprig of male flowers is just being inserted with the right hand; the fiber with which the flowers will be tied in place is held in the mouth. Negative by the author. Fig. 4.—Arabs demonstrat-

ing the pollination of the date palm; the next stage after Fig. 1 above; the cluster of female flowers has been entirely removed from the sheath and is being tied together with a palm-leaf fiber to hold the sprig of male flowers in place. Negative by the author.

Plate IX. Deglet Noor dates from the Sahara Desert. (Natural size.) Photographed at Washington two months after being picked. Above, cut open date and two seeds. Negative by G. N. Collins and the author.

Plate X. Deglet Noor dates packed for the retail trade. The small paper box contains about two-thirds of a pound; the wooden boxes hold about four and one-half pounds. (One-third natural size.) Negative by G. N. Collins and the author.

Plate XI. Date palms growing in basin irrigated by flooding, at Bedrachin, near Cairo, Egypt. The water ranges from a few inches to several feet deep and remains standing about 6 weeks. September, 1902. Negative by Thos. H. Kearney and Thos. H. Means.

Plate XII. Fig trees growing under partial shade afforded by date palms in the oasis of Chetma, Algeria; May, 1900. Negative by the author.

Plate XIII. Date palms in garden at Biskra, Algeria. Soil samples (Biskra, Station No. 1) were secured in the foreground. An Arab is climbing the tall palm in order to pollinate the flowers; May, 1900. Negative by the author.

Plate XIV. Fig. 1.—Date palms growing without artificial irrigation near Fougala, Algeria; at the base of the palm trunks a bank or "goorma" is seen. Fig. 2.—Shallow well with sweep "kitara" used to irrigate date palms at Fougala, Algeria. Negatives by the author.

Plate XV. Fig. 1.—Very alkaline undisturbed Saharan soil at Fougala, Algeria; a scanty growth of salt bushes and samphires is seen in the foreground near where soil sample (Fougala, Station No. 1) was taken; to left, in middle ground, young palms are seen growing in pits. Fig. 2.—Date palm in condition called "meznoon" or crazy, showing youngest leaves dwarfed and distorted; oasis of Fougala, Algeria; May, 1900. Negatives by the author.

Plate XVI. Fig. 1.—Young date palms growing on very alkaline soil at Chegga, Algeria. A white crust of alkali is shown along the edge of the irrigation ditch. A soil sample (Chegga, Station No. 1) was secured near by. Fig. 2.—Young date palms at Chegga, Algeria. A soil sample (Chegga, Station No. 2) was obtained in the bed of oasis alfalfa seen on the left of the drainage ditch; May, 1900. Negatives by the author.

Plate XVII. Fig. 1.—Date plantation on alkaline soil at Ourlana, Algeria, in the Oued Rirh region of the Sahara Desert. A drainage ditch is shown and to right ridges to facilitate irrigation by surface flooding. A soil sample (Ourlana, Station No. 2) was secured between the first two trees on the right. Negative by the author. Fig. 2.—Crescent-shaped excavation, "dahir," at the base of a date palm, to hold irrigation water, Biskra, Algeria. Offshoots ready to remove are seen at the base of the trunk. Negative by the author.

Plate XVIII. Fig. 1.—View in the Salton Basin, near Imperial, Cal., looking southward, showing level, bare desert land, with almost no trace of vegetation; Signal Mountain, in Mexico, in the distance; January, 1901. Fig. 2.—Shore of a dry, salt lake, Chott Merouan, between Chegga and M'raïer, Algeria, with salt-loving vegetation; in the distance a mirage simulates a vast sheet of water, with remote islands covered with bushes. Negative by the author.

Plate XIX. Fig. 1.—A neglected Egyptian date palm growing without irrigation in the Salton Basin, near Indio, Cal., November, 1899. Fig. 2.—Old date palms showing reflexed, dead leaves growing at Hermosillo, northern Mexico; orange

trees grow under the palms; arid hills form the background; December, 1899. Fig. 3.—Fan palm, showing persistent dead leaves clothing the trunk, near Indio, Cal. Fig. 4.—Group of fan palms growing wild in a dry ravine near Indio, Cal., November, 1899. Negatives by the author.

PLATE XX. Fig. 1.—Old date palms growing at San Diego Mission, near San Diego, Cal. Negative by Park & Co., Los Angeles. Fig. 2.—Seedling date palm, showing bunches of nearly ripe fruit, growing without artificial irrigation in the flood-plain of the Colorado River, near Yuma, Ariz.; planted by Mr. Hall Hanlon (who stands beneath), November, 1899. Negative by the author.

PLATE XXI. View in Cooperative Date Orchard at Tempe, Ariz., showing growth made in two years by offshoots imported from North Africa in 1900. Photographed December 31, 1902, by Prof. R. H. Forbes.

PLATE XXII. Three-year-old Deglet Noor date palm in fruit, growing in the Cooperative Date Orchard at Tempe, Ariz., from an offshoot imported from the Sahara Desert in July, 1900. Photographed August 27, 1903, by W. W. Skinner.

FIG 1.—FRUITING DATE PALMS AT OLD BISKRA, ALGERIA, WITH FIG TREES GROWING UNDERNEATH, AUGUST, 1902.

FIG. 2.—DATE PALMS AT OLD BISKRA, ALGERIA. TWO LARGE MALE TREES AT LEFT.

FIG. 1.—NATIVE GARDENERS (ROUARA) AT OURLANA, ALGERIA, PREPARING DATE OFFSHOOTS FOR SHIPMENT BY CAMEL BACK.

FIG. 2.—CARAVAN LOADED WITH DATE PALM OFFSHOOTS FOR ARIZONA, STARTING FROM OURLANA NORTHWARD, MAY, 1900.

FIG. 3.—FINAL TRIMMING OF DATE OFFSHOOTS AT ALGIERS PREPARATORY TO SHIPMENT TO AMERICA, JUNE, 1900.

FIG. 1.—FLOWER CLUSTER OF MALE DATE PALM JUST EMERGED FROM SHEATH AND LETTING POLLEN ESCAPE.

FIG. 2.—THREE FEMALE FLOWER CLUSTERS.

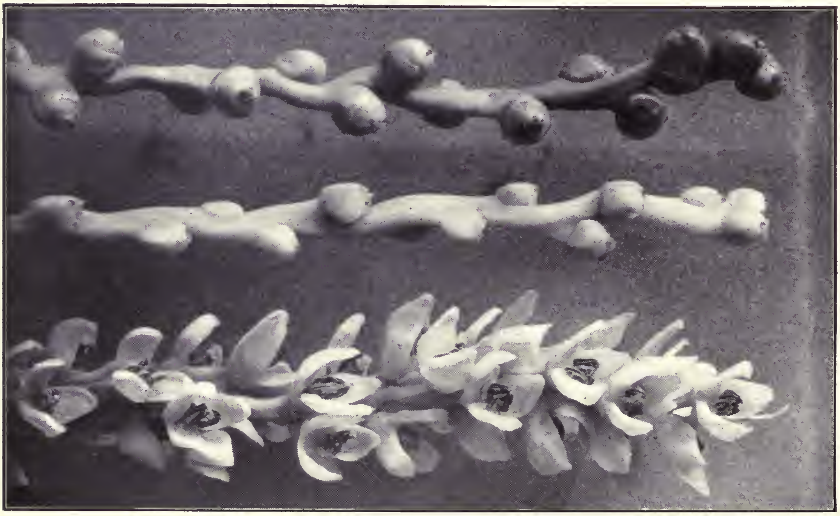

FIG. 3.—MALE AND FEMALE FLOWERS OF THE DATE PALM, MAGNIFIED.

FIG. 1.—FOREST OF OLD DATE PALMS AT BISKRA, ALGERIA, SHOWING ARAB POLLINATING FLOWERS.

FIG. 2.—ARAB POLLINATING A DATE PALM RAMLEY, EGYPT, USING A ROPE AND BROAD BELT IN CLIMBING.

FIG. 3.—ARABS DEMONSTRATING THE POLLINATION OF THE DATE PALM. SPRIG OF MALE FLOWERS BEING INSERTED.

FIG. 4.—CLUSTER OF FEMALE FLOWERS BEING TIED TOGETHER TO HOLD THE SPRIG OF MALE FLOWERS IN PLACE.

DEGLET NOOR DATES FROM THE SAHARA DESERT (NATURAL SIZE).

DEGLET NOOR DATES PACKED FOR THE RETAIL TRADE.

DATE PALMS GROWING IN BASIN IRRIGATED BY FLOODING AT BEDRACHIN, NEAR CAIRO, EGYPT, SEPTEMBER, 1902.

FIG TREES GROWING UNDER PARTIAL SHADE AFFORDED BY DATE PALMS, OASIS OF CHETMA, ALGERIA.

ARAB CLIMBING TALL PALM IN A GARDEN AT BISKRA, ALGERIA, TO POLLINATE THE FLOWERS, MAY, 1900.

FIG. 1.—DATE PALMS GROWING WITHOUT IRRIGATION NEAR FOUGALA, ALGERIA.

FIG. 2.—SHALLOW WELL USED TO IRRIGATE DATE PALMS AT FOUGALA, ALGERIA.

FIG. 1.—VERY ALKALINE UNDISTURBED SAHARAN SOIL AT FOUGALA, ALGERIA. YOUNG PALMS GROWING IN PITS.

FIG. 2.—DATE PALM IN DISEASED CONDITION CALLED "MEZNOON," CAUSED BY EXCESS OF ALKALI, FOUGALA, ALGERIA.

FIG. 1.—YOUNG DATE PALMS GROWING ON VERY ALKALINE SOIL AT CHEGGA, ALGERIA.

FIG. 2.—YOUNG DATE PALMS AND SAHARAN ALFALFA AT CHEGGA, ALGERIA.

FIG. 1.—DATE PLANTATION ON ALKALINE SOIL AT OURLANA, ALGERIA.

FIG. 2.—CRESCENT-SHAPED EXCAVATION AT THE BASE OF A DATE PALM TO HOLD IRRIGATION WATER, BISKRA, ALGERIA.

FIG. 1.—VIEW IN THE SALTON BASIN, NEAR IMPERIAL, CAL., SHOWING LEVEL, BARE DESERT SOIL.

FIG. 2.—SHORE OF A DRY SALT LAKE, CHOTT MEROUAN, BETWEEN CHEGGA AND M'RAÏER, ALGERIA.

FIG. 1.—A NEGLECTED EGYPTIAN DATE PALM GROWING WITHOUT IRRIGATION IN THE SALTON BASIN, NEAR INDIO, CAL.

FIG. 2.—OLD DATE PALMS AT HERMOSILLO, NORTHERN MEXICO, WITH ORANGE TREES GROWING UNDERNEATH.

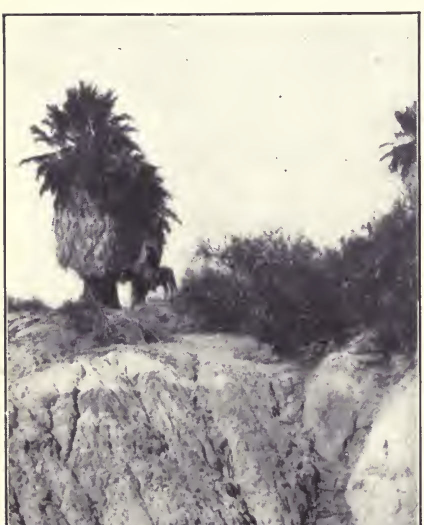

FIG. 3.—FAN PALM SHOWING DEAD LEAVES CLOTHING TRUNK, NEAR INDIO, CAL.

FIG. 4.—GROUP OF FAN PALMS GROWING WILD IN A DRY RAVINE, NEAR INDIO, CAL.

FIG. 1.—OLD DATE PALMS GROWING AT SAN DIEGO MISSION, NEAR SAN DIEGO, CAL.

FIG. 2.—SEEDLING DATE PALM WITH NEARLY RIPE FRUIT, GROWING WITHOUT IRRIGATION IN THE FLOOD PLAIN OF THE COLORADO RIVER IN CALIFORNIA.

VIEW IN COOPERATIVE DATE ORCHARD, TEMPE, ARIZ., SHOWING OFFSHOOTS IMPORTED FROM NORTH AFRICA IN 1900.

THREE-YEAR-OLD DEGLET NOOR DATE PALM IN FRUIT, GROWING IN THE COOPERATIVE DATE ORCHARD AT TEMPE, ARIZ., FROM AN OFFSHOOT IMPORTED FROM THE SAHARA DESERT IN JULY, 1900. PHOTOGRAPHED AUGUST, 1903.

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50. Wild Rice: Its Uses and Propagation. 1903. Price, 10 cents.
51. Miscellaneous Papers: Part I. The Wilt Disease of Tobacco and its Control. 1903. Price, 5 cents. Part II. The Work of the Community Demonstration Farm at Terrell, Texas. 1904. Price, 5 cents.
52. Wither-Tip and Other Diseases of Citrous Trees and Fruits Caused by Colletotrichum Glœosporioides. 1904. Price, 15 cents.